

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

PRAXAIR TECHNOLOGY, INC.,
Petitioner,

v.

ENTEGRIS, INC.,
Patent Owner.

Case IPR2016-01845
Patent 8,237,134 B2

Before KRISTEN L. DROESCH, BRYAN F. MOORE, and
RAMA G. ELLURU, *Administrative Patent Judges*.

DROESCH, *Administrative Patent Judge*.

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

I. INTRODUCTION

A. Background

Praxair Technology, Inc., (“Petitioner”) filed a Petition (Paper 1, “Pet.”) for *inter partes* review of claims 1–20 (“the challenged claims”) of U.S. Patent No. 8,237,134 B2 (“the ’134 Patent”). See 35 U.S.C. §§ 311–312. Pursuant to 35 U.S.C. § 314, we instituted trial on March 30, 2017 as to claims 1–20 of the ’134 Patent. Paper 7 (“Institution Decision” or “Dec.”). Patent Owner filed a Patent Owner Response (Paper 11, “PO Resp.”), and Petitioner filed a Reply (Paper 14, “Reply”). Petitioner relies on Declarations of Ashwini K. Sinha, Ph.D. (“Dr. Sinha”) (Ex. 1002, Ex. 1034). Patent Owner relies on the Declaration of Kevin Jones, Ph.D. (“Dr. Jones”) (Corrected Ex. 2008). Oral argument was held on January 4, 2018. Paper 19 (“Tr.”).

We have authority under 35 U.S.C. § 6. This Final Written Decision is issued pursuant to 35 U.S.C. § 328(a) and 37 C.F.R. § 42.73. For the reasons that follow, we determine Petitioner has shown by a preponderance of the evidence that claims 1–20 of the ’134 Patent are unpatentable.

B. The ’134 Patent (Ex. 1001)

The ’134 Patent discloses an ion implantation system for depositing a desired chemical species into a substrate (e.g., a microelectronic device wafer) by utilizing an ion source to ionize a dopant gas (e.g., a halide or hydride of the dopant species) to generate an ion beam and impinge the energetic ions on the substrate. See Ex. 1001, 1:38–45. Ion source lifetime is a critical characteristic of the ion implantation system because the ion source must be capable of continuous operation for extended periods without shutdown, maintenance, or repair. See *id.* at 1:53–60. Ion source failure can

be caused by: (1) accumulation of deposits on the cathode surfaces thereby reducing performance and shortening lifetime of the ion source, (2) deleterious etching reactions from germanium tetrafluoride dopant gas resulting from free fluorine in the arc chamber; and (3) stripping and sputtering of cathode material resulting in loss of physical integrity of the cathode and reduction in performance and lifetime of the ion source. *See id.* at 1:61–2:3.

The '134 Patent discloses dopant compositions of isotopically enriched germanium compounds, including germanium tetrafluoride (GeF_4) and germane (GeH_4). *See* Ex. 1001, 6:7–29. Isotopically enriched germanium compounds include isotopes of mass 70, 72, 73, 74, and 76 with enrichment levels greater than 21.2%, 51.6%, 7.9%, 37.1%, and 7.4%, respectively. *See id.* at 4:58–5:5; 6:7–29. The '134 Patent further discloses that the dopant compositions include a dopant gas, and a supplemental gas that includes a diluent gas and/or an isotopically enriched co-species gas. *See id.* at 5:6–10; 6:30–34, 59–65; 8:13–23, 57–62.

[I]sotopically enriched dopant gases, and/or isotopically enriched co-species gases, in which the concentration of a beneficial isotope is increased in relation to its natural occurrence in such dopant and/or co-species gases . . . improve the performance and lifetime of the ion source in the ion implantation system, in relation to a corresponding system in which the dopant and/or co-species gases are not isotopically adjusted from natural abundance concentration levels.

Id. at 11:37–45.

C. Illustrative Claims

Of the challenged claims, claims 1 and 15 are independent, with claims 2–14 dependent ultimately from claim 1 and claims 16–20 dependent

ultimately from claim 15. Claims 1, 2, 5, 6, 11, and 14 are illustrative and reproduced below:

1. An ion implantation process, comprising:
flowing a dopant composition to an ion source;
generating ionic dopant species from the dopant composition at the ion source; and
implanting the ionic dopant species in a substrate,
wherein the dopant composition is selected from the group consisting of the following dopant compositions (i) and (ii):
(i) dopant compositions comprising one or more germanium compounds isotopically enriched to above natural abundance level of at least one germanium isotope of mass 70, 72, 73, 74 or 76, wherein the isotopically enriched level of said at least one germanium isotope is greater than 21.2% for mass 70 germanium isotope, greater than 27.3% for mass 72 germanium isotope, greater than 7.9% for mass 73 germanium isotope, greater than 37.1% for mass 74 germanium isotope, and greater than 7.4% for mass 76 germanium isotope; and
(ii) dopant compositions comprising a dopant gas and a supplemental gas, wherein the supplemental gas includes at least one of a diluent gas and a co-species gas, and wherein at least one of the dopant gas and, when present, a co-species gas, is isotopically enriched;
with the proviso that when the dopant composition of dopant composition (i) or isotopically enriched dopant gas or co-species gas of dopant composition (ii) consists of germanium tetrafluoride isotopically enriched in mass 72 germanium isotope, said isotopically enriched level is greater than 51.6% for the mass 72 germanium isotope.

2. The process of claim 1, wherein the dopant composition is selected from the group consisting of dopant compositions (i).

5. The process of claim 2, wherein the one or more isotopically enriched germanium compounds comprise germane and germanium tetrafluoride.

6. The process of claim 1, wherein the dopant composition is selected from the group consisting of dopant compositions (ii).

11. The process of claim 6, wherein said supplemental gas includes one or more diluent gas selected from the group consisting of argon, hydrogen, nitrogen, helium, ammonia, fluorine and xenon.

14. The process of claim 6, wherein the dopant composition comprises a dopant gas formulation selected from the group consisting of:

- (i) xenon, hydrogen, and isotopically enriched germanium tetrafluoride;
- (ii) germane and isotopically enriched germanium tetrafluoride;
- (iii) isotopically enriched germanium tetrafluoride and isotopically enriched germane;
- (iv) xenon, hydrogen, and isotopically enriched boron trifluoride;
- (v) diborane and isotopically enriched boron trifluoride; and
- (vi) isotopically enriched boron trifluoride and isotopically enriched diborane.

D. Grounds of Unpatentability

We instituted review of following claims of the '134 Patent on the following grounds and prior art (Dec. 7–24):

Claims	Statutory Basis	References
1, 2, 4, 6, 7, 9, and 11–20	§ 103	Rendon ¹ , ATMI VAC ² , and Gupta ³
3, 5, 8, 10	§ 103	Rendon, ATMI VAC, Gupta, and Tempel ⁴
1, 2, 4, 6, 7, 9, and 11–20	§ 103	Rendon, Trace ⁵ , and Gupta
3, 5, 8, 10	§ 103	Rendon, Trace, Gupta, and Tempel

II. ANALYSIS

A. Claim Construction

Claims of an unexpired patent are interpreted using the broadest reasonable interpretation in light of the specification. *See* 37 C.F.R. § 42.100(b); *Cuozzo Speed Techs., LLC v. Lee*, 136 S. Ct. 2131, 2144–46 (2016). Under the broadest reasonable interpretation standard, claim terms are given their ordinary and customary meaning as would be understood by one of ordinary skill in the art in the context of the entire disclosure. *In re Translogic Tech., Inc.*, 504 F.3d 1249, 1257 (Fed. Cir. 2007). Any special

¹ Ex. 1006, *Reducing Arsenic to Germanium Cross Contamination with Isotopically Enriched SDS ⁷²GeF₄*, IEEE CONFERENCE ON ION IMPLANTATION TECHNOLOGY, 2000, Rendon et al. (“Rendon”).

² Ex. 1007, *VAC® GEF₄ Isotopically Enriched, VAC Delivery Package for Germanium Tetrafluoride*, ATMI BROCHURE, 2005 (“ATMI VAC”).

³ Ex. 1008, US Patent Application Publication US 2008/0237496 A1, published October 2, 2008 (“Gupta”).

⁴ Ex. 1010, US Patent Application Publication US 2006/0060818 A1, published March 23, 2006 (“Tempel”).

⁵ Ex. 1009, *Enriched Isotopes, Germanium (Ge) Isotopes*, TRACE SCIENCES INTERNATIONAL WEBSITE, 2008 (“Trace”).

definitions for claim terms must be set forth with reasonable clarity, deliberateness, and precision. *See In re Paulsen*, 30 F.3d 1475, 1480 (Fed. Cir. 1994).

Petitioner asserts that the following claim terms are defined in the '134 Patent Specification (Pet. 17–18 (citing Ex. 1001, 4:32–52; Ex. 1002 ¶¶ 87–88)):

Claim Phrase	Definition
“dopant gas”	“a gas-phase material including a dopant species”
“supplemental gas”	“a diluent gas or a co-species gas”
“diluent gas”	“a gas that does not contain the dopant species”
“co-species gas”	“a gas that contains the same dopant species as the dopant gas wherein such same dopant species is coordinated or associated to a non-dopant component that is different from the non-dopant component of the dopant gas”

The '134 Patent provides definitions for the aforementioned claim terms with sufficient clarity, deliberateness and precision. *See* Ex. 1001, 4:32–52. Patent Owner does not explicitly contest Petitioner’s proposed constructions. PO Resp. 7. Accordingly, based on this record we adopt the proposed claim constructions.

We agree with Petitioner that the phrase “selected from the group consisting of,” recited in claims 1, 2, 6, 11–14, and 18–20, indicates a Markush group, and, thereby, recites a list of alternatively useable species. *See* Pet. 18–19. We further agree that the phrases “wherein the one or more isotopically enriched germanium compounds comprise,” recited in dependent claims 3–5, and “wherein the dopant composition comprises,” recited in claims 8–10, further limit the scope of the claims from which they depend. *See id.* at 19–20. Patent Owner does not explicitly disagree with Petitioner’s assertions. *See* PO Resp. 7.

Lastly, we note that the claim 1 recitation “with the proviso that when the dopant composition of dopant composition (i) or isotopically enriched dopant gas or co-species gas of dopant composition (ii) consists of germanium tetrafluoride, isotopically enriched in mass 72 germanium isotope, said isotopically enriched level is greater than 51.6% for the mass 72 germanium isotope,” is a conditional limitation. Therefore, the limitation “said isotopically enriched level is greater than 51.6% for the mass 72 germanium isotope” is triggered only when the dopant composition of Markush groups (i) or (ii) consists of germanium tetrafluoride isotopically enriched in mass 72 germanium isotope. Claim 15 includes a substantially similar conditional limitation.

For the purpose of this Final Written Decision, no additional claim terms require an explicit construction. *See Vivid Techs., Inc. v. Am. Sci. & Eng’g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999) (“[O]nly those terms need be construed that are in controversy, and only to the extent necessary to resolve the controversy.”).

B. Principles of Law

The question of obviousness is resolved on the basis of underlying factual inquiries 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 skill in the art; and 4) the presence of objective indicia of nonobviousness, such as commercial success, unexpected results, industry praise, long-felt but unsolved needs, failure of others, and copying. *See Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966).

An expansive and flexible approach applies to determining whether a claimed invention would have been obvious. *KSR Int’l Co. v. Teleflex Inc.*,

550 U.S. 398, 415 (2007). The Court outlined several principles underlying the Supreme Court’s earlier instructions regarding obviousness, including the following: “[t]he combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results” (*id.* at 416), and “if a technique has been used to improve one device, and a person of ordinary skill in the art would recognize that it would improve similar devices in the same way, using the technique is obvious unless its actual application is beyond his or her skill” (*id.* at 417).

The obviousness inquiry includes the question of “whether the improvement is more than the predictable use of prior art elements according to their established functions.” *KSR*, 550 U.S. at 417. And often it will be necessary “to look to interrelated teachings of multiple patents; the effects of demands known to the design community or present in the marketplace; and the background knowledge possessed by a person having ordinary skill in the art, all in order to determine whether there was an apparent reason to combine the known elements in the fashion claimed by the patent at issue.” *Id.* at 418. The analysis should be made explicit to facilitate review of the obviousness determination. *Id.* (quoting *In re Kahn*, 441 F.3d 977, 988 (Fed. Cir. 2006)). “[R]ejections on obviousness grounds cannot be sustained by mere conclusory statements; instead, there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness.” *Kahn*, 441 F.3d at 988. Yet, “the analysis need not seek out precise teachings directed to the specific subject matter of the challenged claim, for a court can take account of the inferences and creative steps that a person of ordinary skill in the art would employ.” *KSR*, 550 U.S. at 418.

Objective indicia of nonobviousness, when present, must always be considered en route to the determination of obviousness. *See Stratoflex, Inc. v. Aeroquip Corp.*, 713 F.2d 1530, 1538 (Fed. Cir. 1983). It is only a part of the “totality of the evidence;” its mere existence does not control the conclusion of obviousness. *See Richardson-Vicks Inc. v. Upjohn Co.*, 122 F.3d 1476, 1483 (Fed. Cir. 1997) (citations omitted). Objective indicia of nonobviousness “is only relevant to the obviousness inquiry ‘if there is a nexus between the claimed invention and the [objective indicia of nonobviousness].’” *In re Affinity Labs of Tex., LLC*, 856 F.3d 883, 901 (Fed. Cir. 2017) (quoting *Ormco Corp. v. Align Tech. Inc.*, 463 F.3d 1299, 1312 (2006)).

C. Person of Ordinary Skill in the Art

Petitioner asserts that a person of ordinary skill in the art as of February 26, 2010 (the earliest priority date for the ’134 Patent) “had at least a bachelor’s of science degree in chemistry, physics, chemical engineering, or materials science engineering with at least two years’ experience in ion implantation.” Pet. 16–17 (citing Ex. 1002 ¶ 79). Petitioner contends that a person of skill in the art “would have had knowledge of ion implantation considerations, including considerations affecting the effectiveness of ion generation and longevity of ion implantation equipment, and be familiar with gas handling related to ion implantation.” *Id.* at 17 (citing Ex. 1002 ¶ 79).

Patent Owner does not contest Petitioner’s definition for a person of ordinary skill in the art. *See* PO Resp. 8. Moreover, Patent Owner agrees that a person of skill in the art “would have had knowledge of ion implantation considerations, including considerations affecting the

effectiveness of ion generation and longevity of ion implantation equipment, and be familiar with gas handling related to ion implantation.” *Id.* (citing Ex. 2008 ¶¶ 49–51). We agree with and adopt Petitioner’s definition for a person of ordinary skill in the art.

D. Asserted Grounds of Unpatentability

*1. § 103 Unpatentability of Claims 1, 2, 4, 6, 7, 9, and 11–20
over Rendon, ATMI VAC, and Gupta*

a. Overview of Rendon (Ex. 1006)

Rendon teaches that germanium has demonstrated the capability of being implanted into silicon. Ex. 1006, 707⁶. Rendon teaches the gaseous vapor of liquid germanium tetrafluoride (GeF₄) is a common source of germanium for ion beams. *See id.* Rendon teaches that germanium isotopes with atomic mass 74 are usually chosen for implantation because of their natural mass abundance, but cross-contamination issues exist with similar mass dopants such as arsenic. *See id.* Rendon, however, teaches that there are two disadvantages of using GeF₄ as an implant source gas: (1) ion source life can be negatively impacted because heavy Ge deposits in the source area will begin to flake and eventually short out the cathode; and (2) the potential for cross contamination with arsenic due to the close proximity of ⁷⁴Ge to the single isotope of arsenic (i.e., ⁷⁵As). *See id.* To address ion source life, Rendon teaches that one can reduce the amount of time running Ge at one time, or introduce a co-gas, such as argon or nitrogen, to reduce build-up on internal source parts to extend the ion source life. *See id.*

⁶ Refers to original page numbers of document.

Rendon also teaches that the use of isotopically enriched ^{72}Ge to more than 50% abundance improves the available beam current and reduces potential cross contamination. *See* Ex. 1006, 707. Rendon teaches that ATMI Inc. provides samples of Safe Delivery System (SDS) GeF_4 with enrichment of ^{72}Ge to 50%, and explains that this level of enrichment provides a slight throughput increase using ^{72}Ge compared to ^{74}Ge from a natural GeF_4 source. *See id.* at 709, Fig. 5. Figure 6 of Rendon depicts the abundance of SDS Enriched ^{72}Ge is 51.6%. *See id.* at Fig. 5. Rendon further teaches that using ATMI's enriched GeF_4 provides a high level of ^{72}Ge beam current, and improves both throughput and source life. *See id.* at 710.

b. Overview of Gupta (Ex. 1008)

Gupta teaches that an ion source is a critical component of an ion implanter system, and that it is desirable to operate the ion source for extended periods without the need for maintenance or repair. *See* Ex. 1008 ¶ 5. Thus, Gupta teaches that ion source lifetime is a critical performance metric for an ion implanter system. *See id.* Gupta teaches that a common cause of ion source failure is the accumulation of materials on cathode surface during extended use of the ion implanter system resulting in the failure to obtain desired beam currents and shorts between the cathode and source chamber. *See id.* ¶ 11. Gupta further teaches that these problems are significant for germanium ion implantation, and very short lifetimes of ion sources have been observed while operating with GeF_4 dopant gas. *See id.* ¶ 12. Gupta also teaches that the lifetime of the ion source when using halogen-containing or fluorine-containing dopant gases, such as GeF_4 , may be limited by metallic growth (e.g., Tungsten (W) deposits) on the cathode

that may be a function of the concentration of free fluorine radicals in the plasma combining with tungsten from arc chamber walls to form WF_6 . *See id.* ¶¶ 13, 41.

Gupta teaches techniques for improving the performance and extending the lifetime of an ion source include releasing a predetermined amount of dopant into an ion source chamber and releasing a predetermined amount of diluent gas into the ion source chamber to dilute the dopant gas and diminish the rate of metallic growth. *See Ex. 1008* ¶¶ 17, 41. Gupta explains that hydrogen radicals generated from a hydrogen-containing diluent gas may scavenge excessive, free fluorine molecules in the arc chamber to reduce the formation of volatile metal halide, and, therefore, improve the performance and extend the lifetime of ion sources. *See id.* ¶ 42. Gupta teaches, however, that although the ion source life may be extended by using a hydrogen-containing diluent gas, the ion beam current for implanting Ge may be reduced when using a hydrogen-containing diluent gas having a co-species that is different from the species of the dopant gas. *See id.* ¶¶ 45–46. Gupta further teaches that this reduction in beam current may be prevented by using a complementary combination of dopant-diluent gases during ion implantation, while retaining the ion source lifetime advantages. *See id.* ¶ 46. As an example, Gupta teaches GeH_4 gas (i.e., germane) may be a complimentary gas for GeF_4 dopant gas having the same Ge species of interest. *See id.* Gupta explains:

As a result, once the gases are mixed, not only do the free hydrogen and the free fluorine combine to improve the lifetime of the ion source, the presence of the Ge species from both the

dopant gas and the diluent gas may prevent any loss in ion beam current.

Ex. 1008 ¶ 46.

c. Overview of ATMI VAC (Ex. 1007)

ATMI VAC teaches a VAC Package (gas cylinder container) that “is ideal for delivering isotopically enriched germanium tetrafluoride (GeF₄) to the ion implant process.” Ex. 1007, 1. ATMI VAC discloses “Isotopically Enriched Germanium Tetrafluoride Ge-72, 50–52%.” *Id.* at 2. ATMI VAC teaches that two advantages of using isotopically enriched GeF₄ (⁷²Ge) for implants are a significant increase in beam current and an extension of ion source lifetime. *See id.* at 1.

d. Analysis of Claims 1, 2, 4, 6, 7, 9, 12, 13, and 15–19

Petitioner asserts that Rendon and Gupta teach “[a]n ion implantation process, comprising: flowing a dopant composition to an ion source; generating ionic dopant species from the dopant composition at the ion source; and implanting the ionic dopant species in a substrate,” as recited in claim 1. *See* Pet. 26–27 (citing Ex. 1006, 707; Ex. 1007, 1; Ex. 1008 ¶¶ 10, 36, 41, Abstract, Figs. 2, 3A–3C; Ex. 1002 ¶ 102). Claim 1 further recites: “the dopant composition is selected from the group consisting of the following dopant compositions (i) and (ii).” As discussed above in Section II.A., claim 1 is written in Markush format. Thus, it is sufficient to show that the prior art, as combined, teaches or suggests a dopant composition meeting the limitations of one member of the Markush group. *Fresenius USA, Inc. v. Baxter Int’l, Inc.*, 582 F.3d 1288, 1298 (Fed. Cir. 2009) (“the entire element is disclosed by the prior art if one alternative in the Markush group is in the prior art”).

Petitioner asserts that the combination of Rendon, ATMI VAC, and Gupta teaches Markush group (i) alternatively recited in claim 1, and affirmatively recited in dependent claim 2. Specifically, Petitioner asserts that Rendon teaches using a dopant gas composition of germanium tetrafluoride (GeF_4), and mass 72 germanium isotope (^{72}Ge) enriched to 51.6% (i.e., greater than 27.3%), and ATMI VAC teaches isotopically enriched germanium tetrafluoride (GeF_4) enriched to 50–52% in ^{72}Ge . *See* Pet. 27–28 (citing Ex. 1006, 707, 709, 710, Fig. 5; Ex 1007, 1–2). Petitioner’s aforementioned citations also address sufficiently the limitations of dependent claim 4, which recites, “the one or more isotopically enriched germanium compounds comprise germanium tetrafluoride.” *See id.* at 31 (incorporating by reference Pet. 27–28).

Petitioner also contends that the combination of Rendon, ATMI VAC, and Gupta teaches Markush group (ii) alternatively recited in claim 1, recited affirmatively in dependent claim 6, and recited similarly in independent claim 15. *See* Pet. 29–32. Specifically, Petitioner asserts that Rendon and ATMI VAC both disclose isotopically enriched GeF_4 as the dopant gas, and Rendon further teaches “using a diluent supplemental gas (i.e., diluent) such as argon or nitrogen along with the dopant gas (i.e., GeF_4) if the implantation process is depositing the germanium ions too heavily onto the ion source area as a way to reduce build-up of the germanium deposits and extend the source life.” *Id.* at 29 (citing Ex. 1006, 707). Petitioner, however, acknowledges implicitly that the combination of Rendon and ATMI VAC does not teach or suggest the supplemental gas includes a co-species gas, as recited optionally in Markush group (ii) of claim 1. *See id.* Petitioner relies on Gupta for teaching that the

supplemental gas could include a diluent gas and a co-species gas (e.g., germane or GeH_4) containing the same species as the dopant gas species (e.g., germanium tetrafluoride or GeF_4). *See id.* (citing Ex. 1008 ¶¶ 17, 21–22, 46, Abstract). Petitioner’s aforementioned citations to Gupta also address sufficiently the limitations of dependent claims 12 and 19, which recite, the “supplemental gas comprises . . . germane” *See id.* at 34 (citing Ex. 1008 ¶¶ 10, 46; Ex. 1002 ¶¶ 127–128), *id.* at 41 (incorporating by reference Pet. 33–34).

Turning to Petitioner’s reasoning to combine the teachings of the references, Petitioner asserts that the combination of Rendon, ATMI VAC, and Gupta “teaches the same approaches for overcoming the same problems in ion implant processes as the ’134 Patent: the use of isotopically enriched gases and/or supplemental gases to (i) extend ion source lifetime; (ii) increase throughput with higher beam current; (iii) and avoid arsenic cross-contamination.” Pet. 22–23 (citing Ex. 1002 ¶¶ 115–134). Specifically, Petitioner asserts that Rendon discloses the known issues of arsenic cross-contamination where ^{74}Ge is used for ion implantation. *See id.* at 23 (citing Ex. 1006, 707; Ex. 1002 ¶ 117). Petitioner contends that Rendon discloses that running the ion source with ^{74}Ge from natural GeF_4 could cause heavy deposits in the source area that will flake and short out the cathode, and identifies known solutions of reducing the time spent running GeF_4 , or using a co-gas, such as argon or nitrogen. *See id.* (citing Ex. 1006, 707; Ex. 1002 ¶ 117). Petitioner further asserts that Rendon teaches that using isotopically enriched ^{72}Ge to more than 50% abundance is a more viable solution for avoiding arsenic cross-contamination while obtaining a slight increase in throughput over natural ^{74}Ge , and increasing beam current. *See id.* (citing

Ex. 1006, 707, 709; Ex. 1002 ¶¶ 117–118). Petitioner also contends that ATMI VAC teaches the same enriched gas source contemplated by Rendon to overcome the deficiencies of natural Ge, and teaches the same benefits as Rendon: increased beam current, extended source lifetime, and reduction of cross contamination. *See id.* at 23–24 (citing Ex. 1006, 710; Ex. 1007, 1–2; Ex. 1002 ¶ 119).

Petitioner asserts that Gupta teaches that using fluorinated dopant gases causes tungsten to deposit on the cathode, thereby reducing the source lifetime due to the release of free fluorine and its reaction with tungsten source chamber components. *See* Pet. 24 (citing Ex. 1008 ¶¶ 13, 41; Ex. 1002 ¶ 126). Petitioner contends that Gupta teaches using a hydrogen-containing diluent gas to reduce the cathode deposits because hydrogen will preferentially react with the free fluorine over the tungsten. *See id.* (citing Ex. 1008 ¶ 41; Ex. 1002 ¶¶ 126–127). Petitioner asserts that Gupta also teaches that using a hydrogen containing diluent gas that does not have the dopant species can lead to a reduction in beam current, and proposes using a co-species with a dopant gas to counteract a reduction in beam current. *See id.* (citing Ex. 1008 ¶ 45; Ex. 1002 ¶ 128). Thus, Petitioner contends that Gupta specifically discloses the use and benefits of using both a halide (e.g., germanium tetrafluoride (GeF₄)) and hydride (e.g., germane (GeH₄)) of the same dopant species to achieve extended source life without decreased beam current. *See id.* at 25 (citing Ex. 1008 ¶¶ 46–47; Ex. 1002 ¶ 128).

Petitioner contends a person of ordinary skill in the art “would have been motivated to find ways to increase source lifetime and would have combined the teachings of *Rendon* and *ATMI VAC* with *Gupta* to develop an ion implantation process that used isotopically enriched compounds as the

dopant gas along with diluent and co-species gases.” Pet. 21–22 (citing Ex. 1002 ¶¶ 115–134); *see id.* at 25 (citing Ex. 1002 ¶¶ 129–134), *id.* at 29–30 (citing Ex. 1002 ¶¶ 127–134), *id.* at 33 (citing Ex. 1002 ¶¶ 129–134), *id.* at 40 (citing Ex. 1002 ¶¶ 127–134). On the foregoing bases, Petitioner sets forth sufficient articulated reasoning with rational underpinning to establish that one of ordinary skill in the art would have modified the combined teachings of Rendon, ATMI VAC, and Gupta, in view of Gupta’s teachings to include diluent and co-species gases. *See* Pet. 23–25, 29–30; KSR, 550 U.S. at 418 (quoting *Kahn*, 441 F.3d at 988).

Turning to the “with the proviso” conditional limitations of claim 1 and independent claim 15, discussed above in Section II.A., Petitioner acknowledges implicitly that Rendon does not teach or suggest the $^{72}\text{GeF}_4$ dopant gas is “isotopically enriched [to a] level [] greater than 51.6 % for the mass 72 germanium isotope.” *See* Pet. 28, 30–31. Petitioner, however, relies on ATMI VAC for teaching the $^{72}\text{GeF}_4$ dopant gas is enriched to a level greater than 51.6%, namely 50–52% in ^{72}Ge . *See id.* at 28 (citing Ex. 1007, 1–2). Petitioner’s aforementioned citations also address sufficiently the limitations of dependent claims 7 and 16, which recite “one or more germanium compounds isotopically enriched above natural abundance level of at least one germanium isotope of mass . . . 72” *See id.* at 32 (citing, *inter alia*, Ex. 1006, 707, 709; Ex. 1007, 1–2; Ex. 1002 ¶¶ 127–134; incorporating by reference Pet. 29–30), *id.* at 39–40 (incorporating by reference Pet. 32). Likewise, the aforementioned citations address sufficiently the limitations of dependent claims 9, 13, 17, and 18, which recite at least “isotopically enriched germanium tetrafluoride” and at least “germanium tetrafluoride.” *See id.* at 33 (citing, *inter alia*, Ex. 1006, 707,

709; Ex. 1007, 1–2; Ex. 1002 ¶¶ 129–134; incorporating by reference Pet. 29–30), *id.* at 35 (citing Ex. 1006, 707; Ex. 1008 ¶ 10; Ex. 1002 ¶¶ 128–130), *id.* at 40–41 (citing Ex. 1006, 707, 709; Ex. 1007, 1–2; Ex. 1008 ¶¶ 10, 21, 22, 46; Ex. 1002 ¶¶ 127–134; incorporating by reference Pet. 35, 39–40).

Turning to Petitioner’s additional reasoning for combining the teachings of the references, Petitioner asserts that Rendon teaches that using isotopically enriched ^{72}Ge to more than 50% abundance is a viable solution to avoid the known arsenic cross-contamination issue while obtaining a slight increase in throughput, and increasing beam current. *See* Pet. 23 (citing Ex. 1006, 707, 709; Ex. 1002 ¶¶ 117–118). Petitioner contends ATMI VAC teaches that its commercially available isotopically GeF_4 dopant gas source, isotopically enriched in ^{72}Ge to 52% abundance, is the same enriched gas source contemplated by Rendon to overcome the deficiencies of natural abundance Ge, and can be used to achieve the same benefits taught by Rendon, such as increased beam current, extended source lifetime, and reduction of cross-contamination. *See id.* at 23–24 (citing Ex. 1006, 710; Ex. 1007, 1, 2; Ex. 1002 ¶ 119). Petitioner asserts that a person of ordinary skill in the art “considering *Rendon* would have been motivated to incorporate the teachings of *ATMI VAC* to develop an ion implantation process using commercially-available, isotopically enriched compounds, including ^{72}Ge , to extend the ion source lifetime and reduce arsenic contamination.” *Id.* at 21 (citing Ex. 1002 ¶¶ 115–134). On the foregoing bases, Petitioner sets forth sufficient articulated reasoning with rational underpinning to establish that one of ordinary skill in the art would have modified the combined teachings of Rendon and Gupta in view of the ATMI

VAC teachings of GeF₄ dopant gas enriched to greater than 51.6% (i.e., up to 52%) in ⁷²Ge. See Pet. 23–24, 28; KSR, 550 U.S. at 418 (quoting *Kahn*, 441 F.3d at 988).

Patent Owner does not contest Petitioner’s factual assertions and articulated reasons to combine the teachings of the references regarding claims 1, 2, 4, 6, 7, 9, 12, 13, and 15–19. See PO Resp. 1–48. Patent Owner also does not offer objective indicia of nonobviousness regarding claims 1, 2, 4, 6, 7, 9, 12, 13, and 15–19. See *id.*

Accordingly, based on the record before us, we are persuaded by a preponderance of the evidence that Petitioner establishes that claim 1, claims 2, 4, 6, 7, 9, 12, and 13, dependent therefrom, independent claim 15, and claims 16–19, dependent therefrom, are unpatentable over Rendon, ATMI VAC, and Gupta.

e. Analysis of Dependent Claims 14 and 20

Claims 14 and 20 require a dopant composition “comprising a dopant gas and a supplemental gas, wherein the supplemental gas includes at least one of a diluent gas and a co-species gas, and wherein at least one of the dopant gas and, when present, a co-species gas, is isotopically enriched” (claims 1 and 6; claim 15). Claims 14 and 20 further recite that the dopant composition comprises “dopant gas formulation” (claim 14) or “a composition” (claim 20) “selected from the group consisting of,” which, as discussed above in Section II.A., indicates a Markush group listing of alternatively useable species. Claims 14 and 20 include the following Markush group listing of alternatively usable species:

- (i) xenon, hydrogen, and isotopically enriched germanium tetrafluoride;

- (ii) germane and isotopically enriched germanium tetrafluoride;
- (iii) isotopically enriched germanium tetrafluoride and isotopically enriched germane;
- (iv) xenon, hydrogen, and isotopically enriched boron trifluoride;
- (v) diborane and isotopically enriched boron trifluoride; and
- (vi) isotopically enriched boron trifluoride and isotopically enriched diborane.

In addition to Petitioner's factual assertions and reasons for combining the teachings of the references discussed above in Section II.D.1.d., Petitioner contends that the combination of Rendon, ATMI VAC, and Gupta teaches or suggests "germane and isotopically enriched germanium tetrafluoride" recited in Markush group (ii) of claims 14 and 20. *See* Pet. 36–37, *id.* at 41–42 (incorporating by reference Pet. 36–37); *see also id.* at 24–25 (discussing reasons to combine teachings of the references). Petitioner contends that Rendon and Gupta disclose the use of germanium tetrafluoride (GeF₄) as a dopant gas, and Rendon and ATMI VAC disclose the use of isotopically enriched GeF₄ enriched in ⁷²Ge. *See* Pet. 36 (citing Ex. 1006, 707, 709; Ex. 1007, 1–2; Ex. 1008 ¶ 10). Petitioner asserts, "Gupta . . . discloses the benefits of using a dopant gas along with a co-species gas, for example, GeF₄ along with GeH₄ [(germane)]." *Id.* at 36–37 (citing Ex. 1008, Abstract ¶¶ 17, 21–22, 46; Ex. 1002 ¶ 128). More specifically, Petitioner asserts that Gupta teaches using GeF₄ as the dopant species with GeH₄ as a co-species to achieve extended source life without decreased beam current. *See id.* at 24–25 (citing Ex. 1008 ¶¶ 13, 41, 45–47; Ex. 1002 ¶¶ 127–134).

Turning to Petitioner's reasons to combine the teachings of the references, Petitioner contends that a person of ordinary skill in the art "would have found it obvious to combine the teachings from *Rendon* and *ATMI VAC* regarding isotopically enriched GeF₄ enriched in ⁷²Ge with the

use of any combination of the diluent gases or co-species gases discussed in *Gupta*.” Pet. 37 (citing Ex. 1002 ¶¶ 127–134). More specifically, Petitioner asserts that a person of ordinary skill in the art

would have looked for ways to further extend [ion] source lifetime of such [ion implantation] processes without reducing beam current and would have combined the teachings of *Rendon* with *Gupta* to develop an ion implantation process that used isotopically enriched compounds as the dopant gas along with diluent and co-species gases. (Ex. 1002, ¶¶129–134). This is especially relevant given the explicit disclosure in *Gupta* of using GeF_4 as the dopant gas and GeH_4 as the co-species gas, meaning the benefits of *Rendon* would apply in the *Gupta* context. (Ex. 1002, ¶128).

Pet. 25. On the foregoing bases, Petitioner has shown persuasively, with sufficient supporting evidence, that the combination of *Rendon*, ATMI VAC, and *Gupta* teaches or suggests “germane and isotopically enriched germanium tetrafluoride” recited in Markush group (ii) of claims 14 and 20, and has provided sufficient articulated reasoning with rational underpinning to establish that one of ordinary skill in the art would have modified the teachings of *Rendon*, ATMI VAC, and *Gupta*, in view of *Gupta*’s teachings of using germane as a co-species gas. *See KSR*, 550 U.S. at 418 (quoting *Kahn*, 441 F.3d at 988).

Because Petitioner has shown persuasively, with sufficient supporting evidence, that the combination of *Rendon*, ATMI VAC, and *Gupta*, teaches or suggests Markush group (ii) of claims 14 and 20, Petitioner also has shown persuasively that the combination of *Rendon*, ATMI VAC, and *Gupta* teaches or suggests all of the elements of claims 14 and 20. *See Fresenius v. Baxter*, 582 F.3d at 1298 (“the entire element is disclosed by the prior art if one alternative in the Markush group is in the prior art”).

Patent Owner acknowledges that the Institution Decision does not address “xenon, hydrogen, and isotopically enriched germanium tetrafluoride” recited in Markush group (i) of claims 14 and 20. *See* PO Resp. 11; Dec. 16–17. Patent Owner alleges that Petitioner challenges claims 14 and 20 on the basis of Markush groups (i) and (ii). *See* PO Resp. 11; *but see* Pet. 36 (citing Ex. 1008 ¶¶ 38, 40) (“*Gupta* discloses the use of any combination of diluent gases such as argon, xenon, hydrogen, and fluorine along with GeF₄.”), *id.* at 41–42 (incorporating by reference Pet. 36–37). Nonetheless, Patent Owner argues that dopant gas formulation or composition recited in Markush group (i) of claims 14 and 20 would not have been obvious over Rendon, ATMI VAC, and Gupta. PO Resp. 11, 17–24.

Because Petitioner has shown persuasively, with sufficient supporting evidence, that the combination of Rendon, ATMI, and Gupta teaches or suggests Markush group (ii) of claims 14 and 20, and, thereby all of the elements of claims 14 and 20 (*see Fresenius v. Baxter*, 582 F.3d at 1298), we need not address whether Petitioner has shown persuasively that the combination of Rendon, ATMI VAC, and Gupta teaches or suggests Markush group (i) of claims 14 and 20.

We also are not persuaded by Patent Owner’s initial argument that there is no teaching, suggestion, or motivation to combine the teachings of Rendon, ATMI VAC, and Gupta. *See* PO Resp. 12–14. Patent Owner contends: (1) Rendon and ATMI VAC do not disclose or propose combining any isotopically enriched gases like ⁷²GeF₄ with any supplemental gas, such as a co-species gas; (2) Rendon and ATMI VAC do not disclose germane as claimed in group (ii) of claims 14 and 20; (3) Gupta

never teaches the use of any isotopically enriched gases and never discloses or suggests combining a naturally abundant co-species gas with isotopically enriched dopant gases; and (4) none of the cited art proposes combining an isotopically enriched gas with a naturally abundant gas. *See id.* (citing Ex. 2008 ¶¶ 52–54, 59, 60, 61). Patent Owner’s arguments are premised incorrectly on a requirement that the prior art *itself* must explicitly teach or suggest the combination. It is not necessary to find precise teachings in the prior art directed to the specific subject matter claimed because inferences and creative steps that a person of ordinary skill in the art would employ can be taken into account. *KSR*, 550 U.S. at 418. As discussed immediately above, Petitioner has set forth sufficient articulated reasoning with rational underpinning for combining the teachings of Rendon, ATMI VAC, and Gupta.

Patent Owner also contends that the invention of claims 14 and 20 would not have been obvious because, “adding the naturally abundant germane would effectively negate the whole purpose of utilizing isotopically enriched $^{72}\text{GeF}_4$, which was to increase the abundance of ^{72}Ge so the beam current can be increased while reducing cross contamination with ^{75}As .” PO Resp. 16; *see* Ex. 2008 ¶ 65 (stating same). Patent Owner argues, “[t]he primary reason to enrich a dopant gas is to increase the beam current for ***the particular enriched isotope species***. . . . the particular ^{72}Ge isotope.” PO Resp. 14 (citing Ex. 2008 ¶ 62 (stating same)). Patent Owner asserts, “[h]igher ion beam current allows for an increase in throughput as more wafers can be processed per unit time.” *Id.* at 5. Patent Owner further contends that there is no dispute that it is desirable to increase the ion beam

current of the dopant species of interest. *See id.* at 14–15 (quoting Ex. 2009, 47:20–48:7; citing Ex. 2008 ¶ 63).

In support of its arguments, Patent Owner notes that the natural abundance of ^{72}Ge is significantly lower than that of ^{74}Ge . *See* PO Resp. 15 (reproducing Ex. 1006, Fig. 1 (showing ^{72}Ge has 27.7% natural abundance and ^{74}Ge has 36%); citing Ex. 2008 ¶ 64 (stating same)). Patent Owner asserts that “one skilled in the art would have expected that if, for example, **isotopically enriched** $^{72}\text{GeF}_4$ is combined with **naturally abundant** GeH_4 [(germane)], which has a high abundance of ^{74}Ge , the net effect would be to reduce the overall concentration of ^{72}Ge (as compared to using $^{72}\text{GeF}_4$ without germane),” and “would have led to a **decrease** in the beam current for ^{72}Ge .” PO Resp. 15–16 (citing Ex. 2008 ¶ 64); *see* Ex. 2008 ¶ 65 (stating same). Patent Owner argues, “the reduction in ion beam current that would have been expected to occur as a result . . . would dissuade a [person of ordinary skill in the art] from combining an isotopically enriched gas with a natural abundance co-species gas.” PO Resp. 16 (citing Ex. 2008 ¶¶ 64–67).

Patent Owner also asserts that isotopically enriched gases are significantly more expensive than non-enriched gases. *See* PO Resp. 5 (citing Ex. 1005, 72). Patent Owner argues, “[b]ecause companies take on significant expense in enriching the desired dopant species, it is particularly important to have as high a beam current as possible when using an enriched dopant species.” *Id.* (citing Ex. 2008 ¶ 42). Patent Owner further contends that “[d]ue to the significant differences between the costs of enriched and non-enriched materials, a [person of ordinary skill in the art] would not have looked to solutions that dilute the ion beam current.” *Id.* (citing Ex. 2008 ¶ 41).

In response, Petitioner asserts there are two known ways to improve an ion implantation performance—by improving ion source lifetime and improving beam current. *See* Reply 4–5. Petitioner asserts that the use of diluent or co-species gases to improve ion source life was known, and the use of isotopically enriched $^{72}\text{GeF}_4$ was known. *See* Reply 4–9. As to the known use of diluent or co-species gases to improve ion source life, Petitioner asserts that ion source lifetime is affected by metallic deposits on the cathode surface and contends that in the prior art time frame it was known that the metallic growth on the cathode can be reduced by using a diluent gas containing hydrogen because the hydrogen scavenges the free fluorine, reducing the attack of the fluorine on the chamber wall. *See* Reply 4–5 (citing Ex. 1002 ¶¶ 48–51; Ex. 1028: 27:4–9, 30:31–5); Pet. 7 (citing Ex. 1002 ¶¶ 47–50; Ex. 1008 ¶¶ 12, 15, 41). Petitioner explains that when a dopant gas contains fluorine, the free fluorine will combine with the metal (e.g., tungsten) of the ion implantation system chamber walls to create metal fluoride (e.g., WF_6) molecules that decompose and deposit on the cathode surface. *See* Reply 4–5 (citing Ex. 1002 ¶¶ 48–50); Pet. 7 (citing Ex. 1002 ¶¶ 47–50; Ex. 1008 ¶¶ 12, 15, 41). Petitioner notes, “*Gupta* discloses using a halide or halogenated dopant gas [(e.g., germanium tetrafluoride (GeF_4))] in combination with a hydrogen-containing diluent gas [(e.g., germane (GeH_4))] to prevent build-up of tungsten on the cathode, thus improving the source life.” Reply 7 (citing Ex. 1008 ¶ 42; Ex. 1002 ¶ 104); *see* Pet. 11 (citing Ex. 1008 ¶ 42; Ex. 1002 ¶ 104).

Regarding the known use of isotopically enriched $^{72}\text{GeF}_4$, Petitioner asserts that before the filing date of the ’134 Patent, it was also known to use isotopically enriched $^{72}\text{GeF}_4$ to both avoid arsenic-cross contamination

associated with selecting for ^{74}Ge and improve the instantaneous beam current over the instantaneous beam current associated with selecting ^{72}Ge of natural abundance GeF_4 . See Reply 5–6 (citing Ex. 1002 ¶¶ 65–66), *id.* at 8–9 (quoting Ex. 1006, 707; Ex. 1007, 1; citing Ex. 1006, Fig. 5; Ex. 1009, 1; Ex. 1028, 20:23–21:6; Ex. 1002 ¶¶ 65–66, 93); Pet. 8–9 (citing Ex. 1001, 11:11–32; Ex. 1002 ¶¶ 61–65; Ex. 1006, 709; Ex. 1014, 2). Petitioner, however, asserts:

Improvement in beam current does not always mean an increase in instantaneous beam current at the beginning of an ion implant process, because the decreased beam current may be able to be run for a longer period of time due to improved source life, thus resulting in an improvement by way of a larger volume of ions implanted over time.

Reply 6 (citing Ex. 2009, 162:4–163:12). Petitioner further notes that Rendon and ATMI VAC disclose using isotopically enriched $^{72}\text{GeF}_4$ to increase ion source lifetime. See Reply 8–9 (citing Ex. 1007, 1; Ex. 1006, 707); Pet. 9–10 (citing Ex. 1007, 1–2, Ex. 1002 ¶¶ 54, 98), *id.* at 21 (citing Ex. 1002 ¶¶ 115–134), *id.* at 23–24 (citing Ex. 1007, 1; Ex. 1002 ¶ 119), *id.* at 28 (citing Ex. 1006, 707, 710), *id.* at 33 (citing Ex. 1002 ¶¶ 129–134), *id.* at 34 (citing Ex. 1002 ¶¶ 127–128), *id.* at 42–43 (citing Ex. 1002 ¶¶ 116–125).

Petitioner argues that using a diluent gas and using isotopically enriched $^{72}\text{GeF}_4$ “increase the performance of the ion implantation process, but if the methods were combined, the maximum or initial instantaneous beam current would be reduced as compared to using an isotopically enriched dopant gas alone because the ions present per unit volume would decrease by adding a diluent gas to the mixture.” Reply 6 (citing Ex. 1002 ¶ 66). Petitioner contends that using diluent or co-species gases further

increases the ion source life, thereby, enabling the ion implantation process to run for longer at the slightly lower beam current, and over time, the absolute number of ions implanted before a new source is needed is greater compared to not using a diluent gas. *See id.* (citing Ex. 1002 ¶¶ 51–53).

We are not persuaded that the disadvantage of an expected decrease in ion beam current would have dissuaded a person of ordinary skill in the art from combining isotopically enriched $^{72}\text{GeF}_4$, as taught by Rendon and ATMI VAC, with natural abundance co-species gas GeH_4 , as taught by Gupta given the advantages of extending ion source lifetime and reducing arsenic cross-contamination achieved by the combination. “[A] given course of action often has simultaneous advantages and disadvantages, and this does not necessarily obviate motivation to combine.” *Medichem, S.A. v. Rolabo, S.L.*, 437 F.3d 1157, 1165 (Fed. Cir. 2006) (quoted by *Allied Erecting and Dismantling Co., Inc., v. Genesis Attachments, LLC*, 825 F.3d 1373, 1381 (Fed. Cir. 2016)). Stated another way, “[t]he fact that the motivating benefit comes at the expense of another benefit, however, should not nullify its use as a basis to modify the disclosure of one reference with the teachings of another. Instead, the benefits, both lost and gained, should be weighed against one another.” *Id.* (quoting *Winner Int’l Royalty Corp. v. Wang*, 202 F.3d 1340, 1349 n.8 (Fed. Cir. 2000)).

Patent Owner’s arguments focus on increased beam current as a primary reason for utilizing isotopically enriched $^{72}\text{GeF}_4$, but do not address any additional reasons for utilizing isotopically enriched $^{72}\text{GeF}_4$, and do not address any of the benefits of adding a diluent gas or co-species gas, such as germane (GeH_4). *See* PO Resp. 14–20, 27–29; *see* Ex. 2008 ¶¶ 62–63 (discussing the relationship between beam current and throughput or factory

production speed of wafers). For example, as set forth by Petitioner, utilizing isotopically enriched $^{72}\text{GeF}_4$ also provides the advantages of extending ion source lifetime and reducing arsenic cross-contamination, and adding a diluent gas or co-species gas, such as GeH_4 , provides the advantage of further extending ion source lifetime. See Pet. 21–22 (citing Ex. 1002 ¶¶ 115–134), *id.* at 28 (citing Ex. 1006, 707, 710), *id.* at 33 (citing Ex. 1002 ¶¶ 129–134), *id.* at 34–35 (citing Ex. 1002 ¶¶ 127–128).

Patent Owner’s arguments focusing on beam current also stand in opposition to the parties’ agreement that a person of ordinary skill in the art at the time of the invention would have had knowledge of ion implantation considerations affecting the longevity of ion implantation equipment. See Pet. 17 (citing Ex. 1002 ¶ 79); PO Resp. 8 (citing Ex. 2008 ¶¶ 49–51). And “[t]he person of ordinary skill in the art is a hypothetical person who is presumed to know the relevant prior art.” *In re GPAC*, 57 F.3d 1573, 1579 (Fed. Cir. 1995) (citing *Custom Accessories, Inc. v. Jeffrey-Allan Indus., Inc.*, 807 F.2d 955, 962 (Fed. Cir. 1986)); see Pet. 16. The relevant prior art, namely Rendon and ATMI VAC teaches that using isotopically enriched $^{72}\text{GeF}_4$ improves or extends ion source life. See Pet. 3 (quoting Ex. 1007, 1), *id.* at 10 (citing Ex. 1007, 1–2; Ex. 1002 ¶ 98), *id.* at 23–24 (citing Ex. 1007, 1; Ex. 1002 ¶ 119), *id.* at 28 (citing Ex. 1007, 707, 709); Reply 8 (quoting Ex. 1007, 1). And Gupta underscores the importance of increasing the lifetime of an ion source when addressing the desirability of operating an ion source for extended periods of time without the need for maintenance or repair, and explaining the lifetime of the ion source or mean time between failures is a critical performance metric. See Ex. 1008 ¶ 5. Patent Owner’s narrow focus on beam current also stands in opposition to Patent Owner’s

declarant Dr. Jones's acknowledgment that ion source lifetime is a critical characteristic of an ion implantation system. *See* Ex. 2008 ¶ 43 (citing Ex. 1001, 1:58–60). Thus, the evidence of record sufficiently supports a finding that a person of ordinary skill in the art at the time of the invention would have had knowledge of using isotopically enriched $^{72}\text{GeF}_4$ to extend ion source lifetime, and would have understood that extending ion source life is an important purpose.

Rather than focusing only on increasing beam current, we must consider both purposes—extending the ion source life and increasing the beam current—and all advantages and disadvantages in determining whether there was a sufficient reason to combine the teachings of the references. *See Medichem*, 437 F.3d at 1165. For the following reasons, there is insufficient evidence that, as viewed from the perspective of one with ordinary skill in the art at the time of the invention, an expected reduction in beam current/throughput would outweigh further extending the ion source life. Stated another way, on this record there is insufficient evidence to support a finding that extending ion source lifetime, reducing arsenic contamination and increasing beam current by using isotopically enriched $^{72}\text{GeF}_4$ and further extending ion source lifetime by adding a diluent gas or co-species gas, such as germane, would have been outweighed by the concern of an expected reduction in beam current/throughput from adding diluent or co-species gases to high cost isotopically enriched $^{72}\text{GeF}_4$. For example, there is insufficient evidence to demonstrate that a threshold reduction in beam current (e.g., 5% reduction, 50% reduction) and/or a threshold price point for isotopically enriched $^{72}\text{GeF}_4$ would have dissuaded a person of ordinary skill in the art at the time of the invention from adding a

diluent gas or co-species gas, such as germane, to isotopically enriched $^{72}\text{GeF}_4$ for the purpose of further extending the ion source lifetime.

Moreover, when asked about the magnitude of the reduction in beam current that would have occurred upon adding a diluent gas or co-species gas, such as germane, to isotopically enriched $^{72}\text{GeF}_4$, Patent Owner's counsel responded that there is nothing in the record addressing the extent of the beam current decrease, and the relative beam currents. *See* Tr., 26:3–23. And as noted by Petitioner, Dr. Jones admits that he does not know if the cost of replacing an ion source outweighs the cost to run the ion implantation process with a decreased beam current. *See* Reply 19 (citing Ex. 1028, 89:20–23).

Accordingly, based on the record before us there is insufficient evidence to support a finding that the disadvantage of an expected reduction in beam current/throughput from adding a diluent gas or co-species gas, such as germane, to high cost isotopically enriched $^{72}\text{GeF}_4$ would have outweighed the advantages of extending ion source lifetime, reducing arsenic contamination, and increasing beam current by using isotopically enriched $^{72}\text{GeF}_4$ and further extending ion source lifetime by adding a diluent gas or co-species gas, such as germane. Therefore, the record before us does not sufficiently support Patent Owner's arguments that an expected reduction in beam current/throughput from adding a diluent gas or co-species gas, such as germane, to high cost isotopically enriched $^{72}\text{GeF}_4$ would have dissuaded a person of ordinary skill in the art at the time of the invention from combining the teachings of the references.

Patent Owner also alleges unexpected results, praise, and copying as objective indicia of nonobviousness of the invention of claims 14 and 20.

See PO Resp. 20–27. Before ultimately resolving the question of obviousness of the invention of claims 14 and 20, we must first consider Patent Owner’s objective indicia of nonobviousness. See *Graham*, 383 U.S. at 17–18; *Stratoflex*, 713 F.2d at 1538.

Patent Owner argues that the invention of claims 14 and 20 is nonobvious because combining isotopically enriched germanium tetrafluoride with xenon and hydrogen provides unexpected results. See PO Resp. 20–25. Patent Owner contends that Petitioner’s Declarant Dr. Sinha reported in a 2014 conference poster (Ex. 2005⁷, Ex. 1026⁸) that the combination of silicon tetrafluoride (SiF₄) with xenon and hydrogen (Xe/H₂) led to a 10% beam current loss. See *id.* at 20 (reproducing a portion of Ex. 2005, 1; citing Ex. 2005; Ex. 2009, 187:8–15); Ex. 2008 ¶ 73 (Dr. Jones stating the same)). Patent Owner asserts that one of the graphs from the 2014 conference poster discloses that the addition of xenon and hydrogen (Xe/H₂) resulted in reduced beam current compared to when SiF₄ was run by itself. See *id.* at 20–21 (reproducing a portion of Ex. 2005, 1; citing Ex. 2008 ¶¶ 73–75 (Dr. Jones stating the same); Ex. 1026, 1. Patent Owner contends that Dr. Sinha reported similar results in a 2016 paper (Ex. 2004⁹). See *id.* at 21–22 (reproducing Ex. 2004, Fig. 1; citing Ex. 2004, 1–2; Ex.

⁷ *UpTime® New Gas Source for Silicon Implant*, 2014 INTERNATIONAL CONFERENCE ON ION IMPLANTATION TECHNOLOGY, 2014, Sinha et al. (“2014 conference poster”).

⁸ Ex. 1026 is identical to Ex. 2005, but a higher quality reproduction. See Ex. 1034 ¶ 7.

⁹ *UpTime® Si²H₆/SiF₄ Mix for High Productivity Si Implant*, 2016 IEEE (Sep. 26, 2016), Sinha et al. (“2016 paper”).

2005; Ex. 2008 ¶ 76 (Dr. Jones stating the same); Ex. 2009, 186:7–10).

Patent Owner contends,

Dr. Sinha reported [in a 2012 conference poster] on the results of combining isotopically enriched GeF_4 with xenon and hydrogen – precisely what is claimed in part (i) of claims 14 and 20. Dr. Sinha found that the combination provided a “particularly effective means of counteracting the deleterious effects of the halogen cycle in the ion source,” “**increas[ed] the beam current,**” and “**dramatically improve[d] ion source life** during GeF_4 implant.”

PO Resp. 22–23 (quoting Ex. 2003¹⁰, citing Ex. 2009, 153:15–155:18); see Ex. 2008 ¶ 77 (Dr. Jones stating the same); Ex. 1025¹¹. Patent Owner further asserts that Petitioner obtained similar results for isotopically enriched boron trifluoride ($^{11}\text{BF}_3$) with xenon and hydrogen, recited in group (iv) of claims 14 and 20. See *id.* at 23 (citing Ex. 2003, Abstract; Ex. 2009, 155:19–156:10; Ex. 2008 ¶ 77 (Dr. Jones stating same)). Patent Owner argues, “what Dr. Sinha saw from the combination is that it surprisingly and unexpectedly **increased** the beam current when the ion source was run for an extended period of time **and** dramatically extended the ion source life.” *Id.* (citing Ex. 2003); see Ex. 2008 ¶ 78 (Dr. Jones stating the same). Patent Owner further contends,

[b]ased on the teachings of Gupta, a [person of skill in the art] would have expected that the beam current would have decreased, as was observed with the combination of SiF_4 , xenon

¹⁰ *UpTime® Xe/H₂ for Source Life and Beam Current Improvement*, 2012 INTERNATIONAL CONFERENCE ON ION IMPLANTATION TECHNOLOGY, June 25–29, 2012, Sinha et al. (“2012 conference poster”).

¹¹ Ex. 1025 is identical to Ex. 2003, but a higher quality reproduction. See Ex. 1034 ¶ 3.

and hydrogen, and would not have expected that the dopant gas combination would have yielded increased beam current after prolonged operation as compared to the systems that ran a pure GeF₄ or BF₃ dopant gas.

PO Resp. 23–24; *see id.* at 24 (citing Ex. 2008 ¶¶ 78–80).

Patent Owner also argues that Dr. Sinha’s testimony and the 2012 conference poster indicate copying of the invention. *See* PO Resp. 25–26. Patent Owner asserts, “it is highly likely that [Dr. Sinha] or someone from his team came across the application that published as the ’134 Patent during the 9-month period between its September 2011 publication date and the June 2012 poster presentation date,” because Dr. Sinha testified that he conducts a competitive patent review every quarter. *Id.* at 26; *see id.* at 25–26 (reproducing Ex. 2009, 90:9–91; citing Ex. 2011¹²). Patent Owner argues that the striking similarities between groups (i) and (iv) of claims 14 and 20 and the compositions discussed in the 2012 conference poster point to a finding that Petitioner adopted the invention recited in groups (i) and (iv) of claims 14 and 20. *See id.* at 26. Patent Owner further argues that, although the 2012 conference poster was presented as the work of Dr. Sinha, Petitioner, and Applied Materials, the 2012 conference poster provides evidence that Dr. Sinha praised the composition of groups (i) and (iv) of claims 14 and 20, thereby, providing additional evidence of non-obviousness. *See id.* at 26–27 (citing Ex. 2008 ¶¶ 77, 82).

In response, Petitioner argues that Patent Owner’s objective indicia of nonobviousness is not commensurate with the scope of claims 14 and 20. *See* Reply 10. Petitioner contends that Patent Owner ignores that the

¹² PCT Application WO 2011/106750 A2, published September 1, 2011.

Petition asserted that claims 14 and 20 were obvious on the basis of Markush group “(ii) germane and isotopically enriched germanium tetrafluoride” and that *inter partes* review was instituted on the basis of Markush group (ii). *See id.* at 10–11 (quoting Dec. 16–17; citing Pet. 36–37, 59–60). Petitioner asserts that Patent Owner presents no evidence of nonobviousness for Markush group (ii) of claims 14 and 20. *See id.* at 11. Petitioner contends, “the Federal Circuit has repeatedly rejected unexpected results arguments where the evidence was plainly disproportionate to the scope of the claim.” *Id.* at 11 (quoting *In re Peterson*, 311 F.3d 1325, 1331 (Fed. Cir. 2003); *In re Grasselli*, 713 F.2d 731, 743 (Fed. Cir. 1983); *Application of Greenfield*, 571 F.2d 1185, 1189 (CCPA 1978)). Petitioner argues, “the Board cannot conclude on this record that unexpected results limited only to ‘xenon, hydrogen, and isotopically enriched germanium tetrafluoride’ and ‘xenon, hydrogen, and isotopically enriched boron trifluoride’ are commensurate in scope with a claim where the composition is ‘germane and isotopically enriched germanium tetrafluoride.’” *Id.* at 12.

For the following reasons, we do not give substantial weight to Patent Owner’s evidence. Objective indicia of nonobviousness “is only relevant to the obviousness inquiry ‘if there is a nexus between the claimed invention and the [objective indicia of nonobviousness].”” *Affinity Labs of Tex.*, 856 F.3d at 901 (quoting *Ormco*, 463 F.3d at 1312). “[T]here is no nexus unless the evidence presented is ‘reasonably commensurate with the scope of the claims.’” *Classco, Inc., v. Apple, Inc.*, 838 F.3d 1214 (Fed. Cir. 2016) (citing *Rambus Inc. v. Rea*, 731 F.3d 1248, 1257 (Fed. Cir. 2013)). The proponent of the evidence is not required to test every embodiment within the scope of the claims to show unexpected results are reasonably

commensurate in scope with the claims. *See In re Kao*, 639 F.3d 1057, 1068 (Fed. Cir. 2011). “If [the proponent] demonstrates that an embodiment has an unexpected result and provides an adequate basis to support the conclusion that other embodiments falling within the claim will behave in the same manner, this will generally establish that the evidence is commensurate with [the] scope of the claims.” *Id.*; *see also South Alabama Med. Sci. Found. v. Gnosis S.P.A.*, 808 F.3d 823, 827 (Fed. Cir. 2015) (applying “reasonably commensurate in scope with the claims” standard to commercial success).

Patent Owner’s objective indicia of nonobviousness evidence directed to Markush group “(i) xenon, hydrogen, and isotopically enriched germanium tetrafluoride,” and Markush group (iv) “xenon, hydrogen, and isotopically enriched boron trifluoride,” as recited in claims 14 and 20 is not reasonably commensurate with the scope of the claims. Patent Owner does not provide an adequate basis to support the conclusion that other embodiments falling within scope of claims 14 and 20 (e.g., Markush group (ii)), will exhibit the same alleged unexpected results as the embodiments recited in Markush group (i) and Markush group (iv). *See Kao*, 639 F.3d. at 1068. Specifically, Patent Owner’s unexpected results arguments and supporting evidence fail to address other embodiments within the scope of claims 14 and 20, such as Markush group “(ii) germane and isotopically enriched germanium tetrafluoride,” and, therefore, provides insufficient basis to conclude that these other embodiments within the scope of claims 14 and 20 behave in the same manner as Markush group “(i) xenon, hydrogen, and isotopically enriched germanium tetrafluoride” and Markush group “(iv) xenon, hydrogen, and isotopically enriched boron trifluoride.”

See PO Resp. 20–24; Ex. 2003; Ex. 2004; Ex. 2005; Ex. 2008 ¶¶ 73–79; Ex. 2009, 153:15–156:10, 186:7–10, 187:8–15; Ex. 2011. Moreover, when asked if germane and isotopically enriched germanium tetrafluoride have the same unexpected result as xenon, hydrogen and isotopically enriched germanium tetrafluoride, counsel for Patent Owner stated he was unable to point to outside evidence of unexpected results, and did not possess objective indicia of nonobviousness for germane and isotopically enriched germanium tetrafluoride. See Tr. 25:3–10.

Patent Owner also does not provide an adequate basis to support a conclusion that the alleged praise and copying of “xenon, hydrogen, and isotopically enriched germanium tetrafluoride,” recited in Markush group (i), and “isotopically enriched boron trifluoride and isotopically enriched diborane,” recited in Markush group (iv) extends to other embodiments falling within scope of claims 14 and 20, such as Markush group (ii) “germane and isotopically enriched germanium tetrafluoride.” Specifically, Patent Owner’s praise and copying arguments and supporting evidence fail to address other embodiments falling within the scope of claims 14 and 20, such as Markush group “(ii) germane and isotopically enriched germanium tetrafluoride,” and, therefore, provides insufficient basis to conclude that these other embodiments within the scope of claims 14 and 20 were also praised and copied. See PO Resp. 24–27; Ex. 2003; Ex. 2009, 90:9–91:1; Ex. 2008 ¶¶ 25–26, 77, 80–82; Ex. 2011. Accordingly, because it is not reasonably commensurate with the scope of claims 14 and 20, we do not give substantial weight to Patent Owner’s evidence of objective indicia of nonobviousness addressing only Markush groups (i) and (iv) of claims 14 and 20.

We have carefully weighed and evaluated the scope and content of the prior art, the differences between the claimed subject matter and the prior art, and the level of skill in the art, along with the evidence of objective indicia of nonobviousness. Upon careful consideration of the evidence as a whole, and weighing it anew, the evidence supporting obviousness outweighs the evidence of nonobviousness. Accordingly, we are persuaded by a preponderance of the evidence that Petitioner establishes that claims 14 and 20 are unpatentable over Rendon, ATMI VAC, and Gupta.

f. Analysis of Dependent Claim 11

Claim 11 includes the phrase “one or more diluent gas selected from the group consisting of,” which, as discussed above in Section II.A., indicates a Markush group listing of alternatively useable species. Claim 11 includes the following Markush group listing of alternatively usable species: “argon, hydrogen, nitrogen, helium, ammonia, fluorine and xenon.” In addition to Petitioner’s factual assertions, and reasons for combining the teachings of the references discussed above in Sections II.D.1.d. and II.D.1.e., Petitioner contends that “*Rendon* specifically discloses the use of a diluent gas such as argon or nitrogen,” and “*Gupta* specifically discloses the use of diluent gases such as argon, xenon, hydrogen, and fluorine.” Pet. 34 (citing Ex. 1006, 707; Ex. 1008 ¶¶ 38, 40); see *id.* at 33–34 (citing Ex. 1008 ¶ 17; Ex. 1006, 707; Ex. 1002 ¶¶ 127–134; incorporating by reference Pet. 29–30); Reply 9–10 (citing Ex. 1006, 707; Ex. 1008 ¶¶ 15, 40).

Petitioner asserts that a person of ordinary skill in the art “reading *Rendon* in view of *ATMI VAC* and *Gupta* would have seen the benefits to extended ion source lifetime, increased throughput, and reduced arsenic cross-contamination with usage of isotopically enriched GeF₄ in ⁷²Ge, as

disclosed in *Rendon* and *ATMI VAC*, and would have understood that including a supplemental gas, as disclosed in *Gupta*, would further extend the ion source lifetime.” *Id.* at 33 (citing Ex. 1002 ¶¶ 129–134); *see id.* at 40 (citing Ex. 1002 ¶¶ 127–134). On the foregoing bases, Petitioner has shown persuasively, with sufficient supporting evidence, that the combination of *Rendon*, *ATMI VAC*, and *Gupta* teaches or suggests at least one of the supplemental gases recited in claim 11, and has provided sufficient articulated reasoning with rational underpinning to establish that one with ordinary skill in the art would have modified the teachings of *Rendon*, *ATMI VAC*, and *Gupta*, in view of *Gupta*’s teachings of using a supplemental gas. *See KSR*, 550 U.S. at 418 (quoting *Kahn*, 441 F.3d at 988).

Patent Owner argues that the invention of claim 11 would not have been obvious because “the results of the addition of a diluent gas to a dopant gas would not have been reasonably predictable to a [person of ordinary skill in the art] at the time of the invention.” PO Resp. 28; *see* Ex. 2008 ¶ 85 (Dr. Jones stating the same). Patent Owner contends Petitioner’s declarant, Dr. Sinha, in his 2012 conference poster, “reported on the results of combining isotopically enriched GeF₄ with xenon and hydrogen and found that the combination provided a ‘particularly effective means of counteracting the deleterious effects of the halogen cycle in the ion source,’ ‘increase[ed] the beam current,’ and ‘dramatically improve[d] ion source life during GeF₄ implant.’” PO Resp. 28 (citing Ex. 2003); *see* Ex. 2008 ¶ 85 (Dr. Jones stating the same); Ex. 1025; *see also* PO Resp. 22–23 (arguing the same; citing Ex. 2003; Ex. 2009, 153:15–155:18). Patent Owner contends that similar results were observed for isotopically enriched boron trifluoride

($^{11}\text{BF}_3$) with xenon and hydrogen. *See* PO Resp. 28 (citing Ex. 2009, 155:19–156:10; Ex. 2008 ¶¶ 77, 85); *id.* at 23 (arguing the same; citing Ex. 2008 ¶ 77); Ex. 2008 ¶ 85 (Dr. Jones stating the same).

Patent Owner asserts that, in contrast to the results reported in the 2012 conference poster, Dr. Sinha, in his 2014 conference poster, reported on the results of combining silicon tetrafluoride (SiF_4) with xenon and hydrogen and concluded that the combination of SiF_4 with xenon and hydrogen actually led to a 10% beam current loss. *See* PO Resp. 28–29 (quoting Ex. 2005, 1); Ex. 2008 ¶ 86 (Dr. Jones stating the same); *see* Ex. 1026; *see also* PO Resp. 20–21 (arguing the same; reproducing several portions of Ex. 2005). Patent Owner also asserts that Dr. Sinha reported similar results of combining SiF_4 with xenon and hydrogen in his 2016 paper. *See* PO Resp. 29 (quoting Ex. 2004, 2); Ex. 2008 ¶ 86 (Dr. Jones stating the same); *see also* PO Resp. 21–22 (arguing the same; reproducing Figure 1 of Ex. 2004). Patent Owner argues that even though isotopically enriched $^{72}\text{GeF}_4$, isotopically enriched $^{11}\text{BF}_3$, and SiF_4 are all fluorinated gases, they behaved very differently in combination with the same diluent gases. *See* PO Resp. 29; Ex. 2008 ¶ 86 (Dr. Jones stating the same). Patent Owner concludes the combination of an isotopically enriched gas with a diluent gas would not have been predictable to a person of ordinary skill in the art. *See* PO Resp. 29–30 (citing Ex. 2008 ¶¶ 25–26, 86–87); Ex. 2008 ¶ 86 (Dr. Jones stating the same).

In response, Petitioner contends that Dr. Jones's opinion that the results of combining isotopically enriched germanium tetrafluoride and xenon and hydrogen would not have been predictable to a person of ordinary skill in the art is based on factually flawed assumptions without having the

same underlying data for comparison. *See* Reply 12–13, 18. Specifically, Petitioner asserts that the 2014 conference poster (Ex. 2005/Ex. 1026), relied upon by Patent Owner’s declarant Dr. Jones in rendering his opinion, showed highest beam current achieved for certain dopant compositions normalized to the value of SiF₄ alone, while the 2012 conference poster (Ex. 2003/Ex. 1025) does not include a chart of the highest beam current normalized to ⁷²GeF₄ alone or ¹¹BF₃ alone. *See id.* at 12–13 (citing Ex. 2003; Ex. 2005; 2008 ¶¶ 73–79; Ex. 1025; Ex. 1026; Ex. 1034 ¶¶ 3–5; Ex. 1035 ¶¶ 6–9). Petitioner contends,

Dr. Jones did not see normalized beam current graphs for isotopically enriched GeF₄ and BF₃ alone as compared to Xe/H₂ combined with isotopically enriched GeF₄ and BF₃, but instead incorrectly assumed that the words “increasing beam current” in Exhibit 2003/Ex. 1025 meant that isotopically enriched GeF₄ and BF₃ behave different with the addition of Xe/H₂ than SiF₄.

Id. at 14–15 (reproducing a portion of Ex. 1026, 1; citing Ex. 2008 ¶¶ 73–79); *see id.* at 13 (arguing a chart with the highest beam current normalized to GeF₄ alone or BF₃ alone was not presented on Dr. Sinha’s 2012 conference poster; comparing Ex. 2003/Ex. 1025 with Ex. 2005/Ex. 1026).

Petitioner further argues that when Dr. Jones was presented the normalized beam current graph for ¹¹BF₃ and ¹¹BF₃ + Xe/H₂ from a second poster from the same 2014 conference (Ex. 1027¹³) showing the highest beam current for the composition of ¹¹BF₃ + Xe/H₂ was lower than for ¹¹BF₃ alone, Dr. Jones opined that these results were expected. *See* Reply 16–17

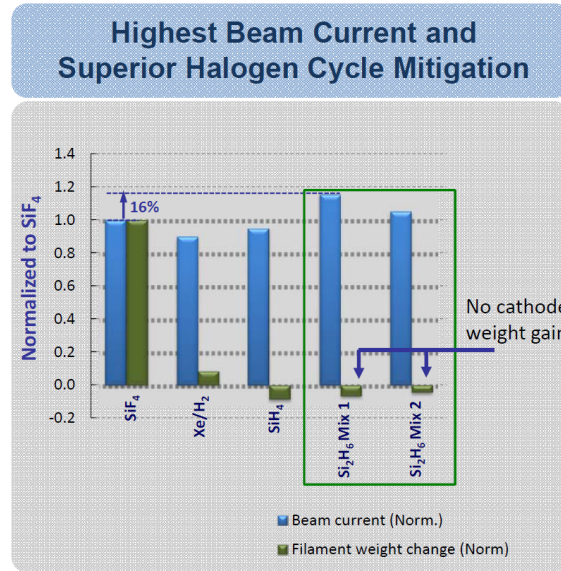
¹³ *UpTime® New Gas Source for Boron Implant*, 2014 INTERNATIONAL CONFERENCE ON ION IMPLANTATION TECHNOLOGY, 2014, Sinha et al. (“second 2014 conference poster”).

(reproducing a portion of Ex. 1027, 1; citing Ex. 1027; Ex. 1028, 66:23–67:7; Ex. 1034 ¶¶ 9–12; Ex. 1035 ¶¶ 10–13). Petitioner also contends that Petitioner’s patent application published on October 12, 2017 (Ex. 1032¹⁴) rebuts Dr. Jones’s false assumptions because it includes a normalized beam current graph for $^{72}\text{GeF}_4$ alone and $^{72}\text{GeF}_4 + \text{Xe}/\text{H}_2$ showing that $^{72}\text{GeF}_4 + \text{Xe}/\text{H}_2$ resulted in a decrease in relative ^{72}Ge ion beam current, normalized to $^{72}\text{GeF}_4$. *See id.* at 17–18 (reproducing Ex. 1032, Fig. 1; citing Ex. 1032; Ex. 1034 ¶¶ 13–15). Petitioner contends that these results are consistent with what Dr. Jones testified he would have expected. *See id.* at 18 (citing Ex. 1028, 66:23–67:7).

We agree that Dr. Jones relied on an incorrect assumption to arrive at his opinion that the results of adding a diluent gas to a dopant gas would not have been reasonably predictable to a person of ordinary skill in the art at the time of the invention. Exhibits 2004 and 2005, utilized by Dr. Jones, both show beam current for SiF_4 and xenon and hydrogen (Xe/H_2) normalized to the beam current of SiF_4 alone, while Exhibit 2003 does not show beam current for $^{72}\text{GeF}_4$ and Xe/H_2 normalized to the beam current for $^{72}\text{GeF}_4$ alone, nor show beam current for $^{11}\text{BF}_3$ and Xe/H_2 normalized to the beam current for $^{11}\text{BF}_3$ alone. The differences in the underlying data can be appreciated by comparing one of the Figures of Ex. 2005/Ex. 1026 to Figure 3 of Ex. 2003/Ex. 1025.

¹⁴ US Patent Application Publication US 2017/0294314 A1, published October 12, 2017.

A Figure from Ex. 1026 is reproduced below.



The Figure from Ex. 1026 is a bar chart summarizing the beam current (blue) and filament weight change (green) of several different dopant gas compositions, including SiF₄ and Xe/H₂ normalized to SiF₄ only. Ex. 2005; Ex. 1026, 1. Figure 1 shows a reduction in beam current for SiF₄ and Xe/H₂ (about 0.9) compared to the normalized beam current for SiF₄ only (1.0).

Figure 3 from Ex. 1025 is reproduced below.

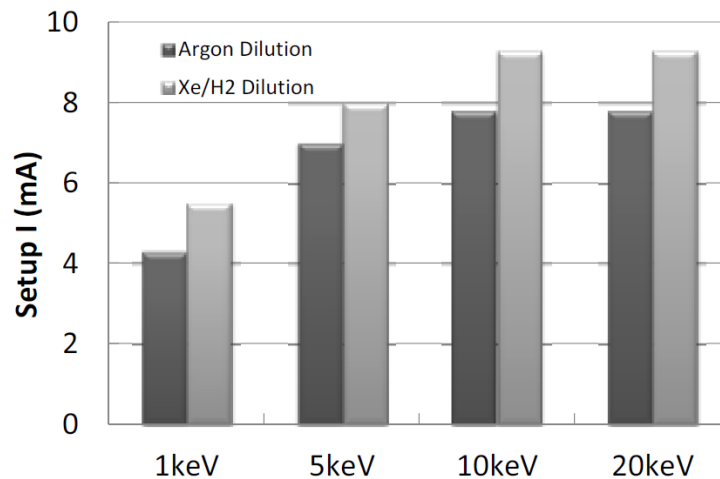


Figure 3 is a bar chart showing higher beam current of $^{72}\text{GeF}_4$ dopant gas with Xe/H₂ dilution (light gray) compared to $^{72}\text{GeF}_4$ dopant gas with Argon dilution (dark grey) at several applied kilo electronvolts. Adjacent to Figure 3, the report states: “Xe dilution provides higher beam current than Ar dilution.” Ex. 2003 at 5; Ex. 1025, Fig. 3.

Although the 2012 conference poster (Ex. 2003/Ex. 1025) reports “the performance benefits of a Xe/H₂ mixture in both improving ion source life and increasing beam current,” the evidence does not sufficiently support Dr. Jones’s assumption that the 2012 conference poster shows $^{72}\text{GeF}_4$ and Xe/H₂ has increased beam current compared to $^{72}\text{GeF}_4$ alone. Patent Owner’s objective evidence is not persuasive of unpredictable results, specifically, an unpredictable increase in beam current from adding a diluent gas to a dopant gas when other evidence predicts the opposite result. At best, Patent Owner’s evidence demonstrates that $^{72}\text{GeF}_4$ dopant gas and Xe/H₂ diluent has a higher beam current than $^{72}\text{GeF}_4$ dopant gas and Argon diluent. See Ex. 2003, Fig. 3; Ex. 1025, Fig. 3. Therefore, on the record before us, the alleged unpredictable results does not sufficiently support Patent Owner’s assertion of nonobviousness.

Patent Owner also argues that a person of skill in the art would not have combined an isotopically enriched gas with the diluent gases recited in claim 11 because such a combination would have led to an undesirable reduction in ion beam current. PO Resp. 27–28 (citing Ex. 2008 ¶¶ 24, 25, 56, 70, 72, 78, 84; incorporating by reference Pet. 11–17). Petitioner relies on the same arguments addressing the expected reduction in beam current discussed above for claims 14 and 20. See PO Resp. 27 (incorporating by reference PO Resp. 11–17; citing Ex. 2008 ¶¶ 63, 84). For the same reasons

as those discussed above in Section II.D.1.e., the record before us does not sufficiently support Patent Owner's arguments that the disadvantage of an expected reduction in beam current/throughput from adding a diluent gas to high cost isotopically enriched $^{72}\text{GeF}_4$ would have dissuaded a person of ordinary skill in the art at the time of the invention from combining the teachings of the references.

Lastly, we are not persuaded by Patent Owner's argument that "[t]he cited prior art fails to teach or suggest a dopant composition comprising an isotopically enriched dopant gas and a diluent gas." PO Resp. 27 (citing Ex. 2008 ¶ 83); *see also id.* at 12 ("Rendon and ATMI VAC do not disclose or propose combining any **isotopically enriched** gases like $^{72}\text{GeF}_4$ with any supplemental gas, such as a . . . diluent gas" (citing Ex. 2008 ¶ 59)). Patent Owner's arguments are premised incorrectly on a requirement that the prior art *itself* explicitly teach or suggest the combination. It is not necessary to find precise teachings in the prior art directed to the specific subject matter claimed. *See KSR*, 550 U.S. at 418. Rather, inferences and creative steps that a person of ordinary skill in the art would employ can be taken into account. *See id.* As discussed immediately above, Petitioner has set forth sufficient articulated reasoning with rational underpinning for combining the teachings of Rendon, ATMI VAC, and Gupta.

Based on the foregoing analysis, we are persuaded by a preponderance of the evidence that Petitioner establishes that claim 11 is unpatentable over Rendon, ATMI VAC, and Gupta.

2. § 103 Unpatentability of Claims 3, 5, 8, and 10
over Rendon, ATMI VAC, Gupta, and Tempel

a. Overview of Tempel (Ex. 1010)

Tempel teaches ionic, liquid-based mixtures for gas storage and delivery used in the semiconductor manufacturing industry. See Ex. 1010

¶¶ 2–4. Tempel discloses:

a mixture for storage and delivery of a gas comprising: an ionic liquid having Lewis basicity and comprising an anion . . . and a cation . . . ; the gas wherein at least a portion of the gas is reversibly chemically reacted with the ionic liquid to provide a chemically reacted gas wherein the chemically reacted gas has Lewis acidity and is selected from . . . germane, germanium tetrafluoride, . . . isotopically-enriched analogs, and mixtures thereof; and optionally an unreacted gas.

Ex. 1010 ¶ 6. Tempel further discloses “the mixture may contain a gas that is used, for example, as a reagent for an ion implant process” *Id.* ¶ 11.

b. Analysis of Claims 3, 5, 8, and 10

Petitioner relies on many of the same combined teachings of Rendon, ATMI VAC, and Gupta, as discussed above in Sections II.D.1.d. through II.D.1.f. to address dependent claims 3, 5, 8, and 10. Compare Pet. 42–46, with, Pet. 21–42. Petitioner acknowledges implicitly that the combination of Rendon, ATMI VAC, and Gupta does not teach or suggest compositions that comprise isotopically enriched germane, as required by claims 3 and 8, or that comprise isotopically enriched germane and isotopically enriched germanium tetrafluoride, as required by claims 5 and 10. See Pet. 42–44. Petitioner asserts that Tempel is directed to an ionic gas used in ion implant processes and specifically teaches the use of germane, germanium tetrafluoride, isotopically-enriched analogs, and mixtures thereof. See *id.* at

43 (quoting Ex. 1010 ¶ 11), *id.* at 45 (quoting Ex. 1010 ¶ 6), *id.* at 46 (citing Ex. 1010 ¶ 6; Ex. 1002 ¶ 137). Petitioner contends that Tempel teaches the use of isotopically enriched GeH₄ in combination with isotopically enriched GeF₄. *See id.* at 43 (citing Ex. 1010 ¶ 6; Ex. 1002 ¶ 137), *id.* at 46 (citing Ex. 1010 ¶ 6; Ex. 1002 ¶ 137).

Turning to Petitioner's reasons for combining the teachings of the references, Petitioner contends that it would have been obvious to modify the combined teachings of Rendon, ATMI VAC, and Gupta with Tempel's teachings of using isotopically enriched germane and isotopically enriched germanium tetrafluoride. *See* Pet. 42–46 (citing Ex. 1002 ¶¶ 136–140).

Petitioner asserts a person of ordinary skill in the art,

would have looked for ways to further increase source lifetime of such processes and would have combined the teachings of *Tempel* with *Rendon* and *Gupta* to devise an ion implantation process that used isotopically enriched co-species gases in combination with isotopically enriched dopant gases, or isotopically enriched either the co-species or the dopant gas.

Pet. 43–44 (citing Ex. 1002 ¶ 138). Petitioner also contends that a person of ordinary skill in the art would have easily recognized that the benefits of using isotopically enriched gases discussed in Rendon and ATMI VAC, would be applicable to other isotopically enriched gases besides GeF₄, especially since these gases were known. *See id.* at 44 (citing Ex. 1002 ¶¶ 139–140); *see also id.* at 45–46 (citing Ex. 1002 ¶¶ 139–140). More specifically, Petitioner contends, a person of ordinary skill in the art

reading *Tempel* in view of *Rendon* and *Gupta* would be motivated to apply the benefits of isotopically enriched GeF₄ in ⁷²Ge to extend the ion source lifetime and reduce arsenic contamination as taught in *Rendon* to any of the germanium

dopant gases and/or germanium co-species gases disclosed in *Gupta* and *Tempel*, including GeH₄.

Pet. 44 (citing Ex. 1002 ¶¶ 136–138). On the foregoing bases, Petitioner has shown persuasively, with sufficient supporting evidence, that the combination of Rendon, ATMI VAC, Gupta, and Tempel teaches or suggests the limitations recited in claims 3, 5, 8, and 10, and has provided sufficient articulated reasoning with rational underpinning to establish that one of ordinary skill in the art would have modified the combined teachings of Rendon, ATMI VAC, and Gupta, in view of Tempel's teachings of using isotopically enriched germanium tetrafluoride (GeF₄) and isotopically enriched germane (GeH₄). *See KSR*, 550 U.S. at 418 (quoting *Kahn*, 441 F.3d at 988).

Patent Owner contends that claims 3, 5, 8, and 10 would not have been obvious because Tempel teaches away from the storage solutions disclosed in ATMI VAC and Rendon by criticizing metal cylinders storing liquefied gas under high-pressure and low-pressure storage and delivery systems that adsorb gases onto a solid support. *See* PO Resp. 30–32 (quoting Ex. 1010 ¶¶ 2–3; Ex. 1007, 1; citing Ex. 1010 ¶¶ 2–3, Ex. 1002; Ex. 1006; Ex. 1007, 2; Ex. 2008 ¶¶ 89–91; *Galderma Labs., L.P. v. Tolmar, Inc.*, 737 F.3d 731 (Fed. Cir. 2013); *Meiresonne v. Google, Inc.*, 849 F.3d 1379, 1383 (Fed. Cir. 2017)). Patent Owner asserts that because Tempel describes high-pressure storage solutions as unacceptable, indicating that such systems demand replacement, a person of ordinary skill in the art would not have combined the high-pressure storage system of ATMI VAC with Tempel. *See id.* at 33 (citing Ex. 2008 ¶ 93). Patent Owner further argues that because Tempel describes low-pressure storage solutions as

suffering from poor capacity and delivery limitations, and poor thermal conductivity, a person of ordinary skill in the art would have been led to discard low-pressure storage solutions and would not have combined Rendon's low-pressure storage solution with Tempel. *See id.* at 34 (citing Ex. 2008 ¶ 94).

In response, Petitioner asserts the Federal Circuit has held that the prior art references must discourage the asserted combination or imply that the resulting combination would not work as described in the patent in order to show teaching away. *See* Reply 25 (citing *Meiresonne*, 849 F.3d at 1384). Petitioner asserts that Patent Owner's arguments ignore that Tempel is included in the ground of unpatentability because it discloses dopant compositions containing isotopically enriched GeH₄ combined with isotopically enriched GeF₄. *See id.* (citing Pet. 42–46). Petitioner contends, “*Tempel* does not discourage using more than one isotopically enriched gas, nor does it disclose that it would result in an unusable dopant composition.” *Id.* Petitioner further argues that the '134 Patent does not claim a specific storage and delivery system for use with its ion implantation process. *See id.* at 22 (quoting Ex. 1001, claim 1).

“Under the proper legal standard, a reference will teach away when it suggests that the developments flowing from its disclosures are unlikely to produce the objective of the applicant's invention.” *Syntex (U.S.A.) LLC v. Apotex, Inc.*, 407 F.3d 1371, 1380 (Fed. Cir. 2005) (citing *In re Gurley*, 27 F.3d 551, 553 (Fed. Cir. 1994)). “A reference does not teach away, however, if it . . . does not ‘criticize, discredit, or otherwise discourage’ investigation into the invention claimed.” *DePuy Spine, Inc. v. Medtronic*

Sofamor Danek, Inc., 567 F.3d 1314, 1327 (Fed. Cir. 2009) (quoting *In re Fulton*, 391 F.3d 1195, 1201 (Fed. Cir. 2004)).

We are not persuaded that Tempel teaches away from the claimed invention. Although Tempel criticizes high-pressure liquefied gas storage and low-pressure storage and delivery systems, Patent Owner's arguments are not germane to whether Tempel teaches away from the claimed invention. Tempel does not criticize, discredit, or otherwise discourage gas compositions comprising isotopically enriched germanium tetrafluoride (GeF_4) and isotopically enriched germane (GeH_4), as recited in claims 3, 5, 8, and 10. As noted by Petitioner, the '134 Patent claims do not recite a specific delivery and storage system for dopant and supplemental gases. *See* Reply 22. In particular, dependent claims 3, 5, 8, and 10 require neither a high-pressure liquefied gas storage nor a low-pressure storage and delivery system, the systems from which Patent Owner alleges that Tempel teaches away.

Related to its argument that Tempel teaches away, Patent Owner contends that claims 3, 5, 8, and 10 would not have been obvious because a person of ordinary skill in the art "considering Rendon, ATMI VAC, and Gupta would not have been motivated to combine with Tempel," and "would not have known how to combine the ionic liquid based storage systems disclosed in Tempel with the storage systems disclosed in Rendon or ATMI VAC, let alone both." PO Resp. 34; *see also id.* at 38–39 (arguing Dr. Sinha could not explain how Tempel would be used with the other prior art; citing Ex. 2009, 108:8–110:21; Ex. 2008 ¶ 102). More specifically, Patent Owner asserts that a person of ordinary skill in the art would not have looked to Tempel's ionic liquid storage solution for combining with Rendon

or ATMI VAC because the ionic storage solution in Tempel leads to significant costly and undesirable gas loss due to reaction reversibility and added complexity. *See id.* at 34–35 (citing Ex. 1010 ¶¶ 6, 84, 89, 96, 98, 100, 102, 104, 108; Ex. 2008 ¶¶ 27, 96–97; Ex. 2009, 115:18–116:13); *see also id.* at 39–40 (arguing selection of an ionic liquid compatible with a particular gas and does not result in product loss is a challenging task; quoting Ex. 1010 ¶ 6; citing Ex. 1010 ¶¶ 84, 89, 96, 98, 100, 102, 104, 108; Ex. 2008 ¶ 103).

We are not persuaded by Patent Owner’s arguments, because, as noted by Petitioner, they are premised incorrectly on bodily incorporating Tempel’s ionic liquid based storage systems with the gas storage and delivery systems taught by Rendon and/or ATMI VAC. *See* Reply 20–21 (citing *In re Keller*, 642 F.2d 413, 425 (CCPA 1981)). Petitioner does not propose combining the storage and delivery systems disclosed by Tempel with the storage and delivery systems of Rendon and/or ATMI VAC. *See* Pet. 42–46, 64–67. As noted by Petitioner, Tempel is relied upon for teaching dopant compositions containing isotopically enriched GeH₄ combined with isotopically enriched GeF₄. *See* Reply 25; Pet. 42–46.

Also related to Patent Owner’s previous arguments, Patent Owner asserts that Petitioner “failed to find the limitations of claims 3, 5, 8, and 10 in the relevant field” and utilized hindsight reconstruction “to fill the gap with Tempel.” PO Resp. 38 (citing *In re Fine*, 837 F.2d 1071, 1075 (Fed. Cir. 1988)). Patent Owner contends that “locating a single claimed dopant gas element in the prior art, and then asserting that inclusion of the element would have been obvious because the gases were known—is a lens through which virtually any invention would appear obvious.” *Id.* Patent Owner

argues “[t]he analysis of whether a [person of ordinary skill in the art] would have been motivated to combine elements of different references does not depend on the recitation in the claims, but looks to whether the references proposed to be combined were compatible with each other and likely to succeed.” *Id.* at 36 (citing *Broadcom Corp. v. Emulex Corp.*, 732 F.3d 1325, 1334–35 (Fed. Cir. 2013)). Patent Owner contends that a person of ordinary skill in the art would not have considered Tempel relevant when trying to design a dopant composition that improves ion beam current and enhances ion source lifetime because Tempel relates to storage of gases in ionic liquid and aims to replace problematic prior art storage solutions such as those described in Rendon and ATMI VAC. *See id.* at 36–37 (citing Ex. 1010 ¶¶ 2–3). Patent Owner contends that the storage of gases in ionic liquids would be particularly problematic for the expensive isotopically enriched gases. *See id.* at 37 (citing Ex. 2008 ¶¶ 98–99). Patent Owner further asserts that both Dr. Sinha and Dr. Jones were not familiar with ionic liquids for ion implantation. *See id.* (citing Ex. 2008 ¶ 100; Ex. 2009, 99:9–16, 108:6–107:10, 110:15–21, 115:1–5). Patent Owner argues that a person of ordinary skill in the art “would not have found the Tempel reference relevant and would not have looked to it when trying to design dopant compositions for ion implantation.” *Id.* at 37–38 (citing Ex. 2008 ¶ 101).

In response, Petitioner contends that Patent Owner’s “arguments that *Tempel* is essentially non-analogous art fall[] short.” *See* Reply 23. Petitioner asserts that Tempel, like Rendon and Gupta, is directed to the storage and delivery of a gas for an ion implantation process. *See id.* (citing Ex. 1010 ¶¶ 4, 11). Petitioner also points out that Gupta contemplates a variety of delivery methods for the dopant gas also shows that those of

ordinary skill in the art considered teachings independent of the disclosed storage container. *See id.* at 22 (citing Ex. 1008 ¶ 39). Petitioner further argues, with supporting testimony by Dr. Sinha, that “[a] variety of storage and delivery systems could be used for ion implantation without impacting the ion implantation process because the chemistry is the same regardless of where the molecule is coming from.” *Id.* (citing Ex. 2009, 137:18–138:9).

We are not persuaded by Patent Owner’s arguments premised incorrectly on a requirement that the proposed combination of the teachings of the references must include Tempel’s ionic liquid storage and delivery system. As pointed out before, Petitioner relies on Tempel’s teachings of isotopically enriched germanium tetrafluoride (GeF₄) in combination with isotopically enriched germane (GeH₄). The intended use of Tempel’s gases in an ionic liquid storage and delivery system, however, need not be preserved as Patent Owner suggests. Rather “[a] reference must be considered for everything it *teaches* by way of technology and is not limited to the particular *invention* it is describing and attempting to protect.” *EWP Corp. v. Reliance Universal Inc.*, 755 F.2d 898, 907 (Fed. Cir. 1985) (emphasis omitted). It also is erroneous to assume

that a person of ordinary skill attempting to solve a problem will be led only to those elements of prior art designed to solve the same problem. . . . Common sense teaches, however, that familiar items may have obvious uses beyond their primary purpose, and in many cases a person of ordinary skill will be able to fit the teachings of multiple patents together like pieces of a puzzle.

KSR, 550 U.S. at 420.

Although Tempel does not address improving ion beam current and enhancing ion source life, we are not persuaded that a person of ordinary

skill in the art would have found Tempel irrelevant when trying to design a dopant composition that improves ion beam current and enhances ion source lifetime because Tempel teaches storing gases in ionic liquids. See PO Resp. 36–40; Ex. 2008 ¶¶ 98–104. We remain persuaded that a person of ordinary skill in the art, similar to fitting together puzzle pieces, “would have looked for ways to further increase source lifetime . . . and would have combined the teachings of *Tempel* with *Rendon*[, *ATMI VAC*,] and *Gupta* to devise an ion implantation process that used isotopically enriched co-species gases in combination with isotopically enriched dopant gases, or isotopically enriched either the co-species or the dopant gas,” and “would [have] been motivated to apply the benefits of isotopically enriched [⁷²]GeF₄ to extend the ion source lifetime and reduce arsenic contamination as taught in *Rendon* to any of the germanium dopant gases and/or germanium co-species gases disclosed in *Gupta* and *Tempel*, including GeH₄.” Pet. 43–44. In other words, a person of ordinary skill in the art would have recognized that the technique of isotopically enriching GeF₄ dopant gas in ⁷²Ge to extend the ion source lifetime and reduce arsenic contamination, would improve the similar co-species gas GeH₄ in the same way. The use of the same technique for a similar gas is obvious unless its actual application is beyond the skill of one with ordinary skill in the art. See *KSR*, 550 U.S. at 417.

For the foregoing reasons, we are persuaded that by a preponderance of the evidence that Petitioner establishes that claims 3, 5, 8, and 10 are unpatentable over *Rendon*, *ATMI VAC*, *Gupta*, and *Tempel*.

3. § 103 Unpatentability of Claims 1, 2, 4, 6, 7, 9, and 11–20
over Rendon, Trace, and Gupta

a. Overview of Trace (Ex. 1009)

Petitioner asserts Trace is a website published before August 28, 2008 by Trace Sciences International. See Pet. 11; Ex. 1020. Trace teaches several enriched germanium isotopes including ^{72}Ge enriched to 82–98+% abundance. Ex. 1009, 1. Trace discloses, “[t]he use of Ge-72, in the form of GeF_4 [(germanium tetrafluoride)], improves th[e] [semiconductor pre-amorphisation implant] process and reduces contamination.” *Id.*; see Ex. 1002 ¶ 107.

b. Analysis of Claims 1, 2, 4, 6, 7, 9, 12, 13, and 15–19

Petitioner asserts that Rendon and Gupta teach “[a]n ion implantation process, comprising: flowing a dopant composition to an ion source; generating ionic dopant species from the dopant composition at the ion source; and implanting the ionic dopant species in a substrate,” as recited in claim 1. See Pet. 52–53 (citing Ex. 1006, 707; Ex. 1008 ¶¶ 10, 36, 41, Abstract; Ex. 1009, 1; incorporating by reference Pet. 26–27). Claim 1 further recites: “the dopant composition is selected from the group consisting of the following dopant compositions (i) and (ii).” As discussed above in Section II.A., claim 1 is written in Markush format. Thus, it is sufficient to show that the prior art, as combined, teaches or suggests a dopant composition meeting the limitations of one member of the Markush group. See *Fresenius v. Baxter*, 582 F.3d at 1298.

Petitioner asserts that the combination of Rendon, Trace, and Gupta teaches Markush group (i) alternatively recited in claim 1, and affirmatively recited in dependent claim 2. Specifically, Petitioner asserts that Rendon

teaches using a dopant gas composition of germanium tetrafluoride (GeF_4), and ^{72}Ge enriched to 51.6% (i.e., greater than 27.3%) and Trace teaches the commercial availability of ^{72}Ge isotope enriched to levels greater than 51.6%. *See* Pet. 53 (citing Ex. 1006, 707, 709, 710, Fig. 5; Ex 1009, 1; Ex. 1002 ¶¶ 142–147; incorporating by reference Pet. 27–28), *id.* at 55 (citing Ex. 1006, 707, 709, 710, Fig. 5; Ex 1009, 1; Ex. 1002 ¶¶ 142–147; incorporating by reference Pet. 53). Petitioner’s aforementioned citations also address sufficiently the limitations of dependent claim 4, which recites, “the one or more isotopically enriched germanium compounds comprise germanium tetrafluoride.” *See id.* at 56 (citing Ex. 1006, 707, 709; Ex. 1009, 1; Ex. 002 ¶¶ 142–147; incorporating by reference Pet. 53–54).

Petitioner also contends that the combination of Rendon, Trace, and Gupta teaches Markush group (ii) alternatively recited in claim 1, recited affirmatively in dependent claim 6, and recited similarly in independent claim 15. *See* Pet. 54–56, 60–61. Specifically, Petitioner asserts that Rendon and Trace both disclose isotopically enriched GeF_4 as the dopant gas, and Rendon teaches “using a diluent gas, such as argon or nitrogen, along with the dopant gas GeF_4 .” *Id.* at 54 (citing Ex. 1006, 707; Ex. 1008 ¶¶ 17, 21–22, 46; Ex. 1009, 1; Ex. 1002 ¶¶ 149–156). Petitioner, however, acknowledges implicitly that Rendon and Trace do not teach or suggest the supplemental gas includes a co-species gas. *See id.* Petitioner relies on Gupta for teaching that the supplemental gas could include a diluent gas and a co-species gas (e.g., germane or GeH_4) containing the same species as the dopant gas species (e.g., germanium tetrafluoride or GeF_4). *See id.* (citing Ex. 1008 ¶¶ 17, 21–22, 46; Ex. 1002 ¶¶ 149–156; incorporating by reference Pet. 29–30). Petitioner’s aforementioned citations to Gupta also

address sufficiently the limitations of dependent claims 12 and 19, which recite the “supplemental gas comprises . . . germane” *See id.* at 58 (citing Ex. 1008 ¶¶ 10, 46; Ex. 1002 ¶¶ 149–150, 152–155), *id.* at 63 (citing Ex. 1006, 707; Ex 1008 ¶¶ 10, 38, 40, 46; incorporating by reference Pet. 57–58).

Turning to Petitioner’s reasons to combine the teachings of the references, Petitioner asserts that Rendon, Trace, and Gupta “teach the same approaches for overcoming the same problems described in the ’134 Patent . . . includ[ing]: the use of isotopically enriched gases and/or supplemental gases to (i) extend ion source lifetime, (ii) increase throughput with higher beam current, (iii) and avoid arsenic cross-contamination.” Pet. 47–48 (citing Ex. 1002 ¶¶ 115–134, 141–156). Specifically, Petitioner asserts that Rendon discloses the known issue of arsenic cross-contamination where ^{74}Ge is used for ion implantation. *See id.* at 48 (citing Ex. 1006, 707; Ex. 1002 ¶ 143). Petitioner also asserts that Rendon discloses that running the ion source with ^{74}Ge from natural GeF_4 could cause heavy deposits in the source area that will flake and short out the cathode, and identifies known solutions of reducing the time spent running GeF_4 or using a co-gas, such as argon or nitrogen. *See id.* (citing Ex. 1006, 707; Ex. 1002 ¶ 142). Rendon discloses another known solution of using isotopically enriched ^{72}Ge to more than 50% abundance as a more viable solution for avoiding arsenic cross-contamination while obtaining a slight increase in throughput over natural ^{74}Ge , and increasing beam current. *See id.* (citing Ex. 1006, 707, 709; Ex. 1002 ¶¶ 143–144). Petitioner also contends that Trace teaches the commercial availability of ^{72}Ge to 85–99+% and the same benefit of reducing cross contamination, asserting that Trace teaches the same type of

enriched gas source contemplated by Rendon to overcome the deficiencies of natural ^{74}Ge implants. *See id.* at 50 (citing Ex. 1006, 707; Ex. 1009, 1; Ex. 1002 ¶ 146).

Petitioner asserts that, according to Gupta, using fluorinated dopant gases causes tungsten to deposit on the cathode, and, thereby, reduce the source lifetime due to the release of free fluorine and its reaction with tungsten source chamber components. *See* Pet. 48 (citing Ex. 1008 ¶¶ 13, 41; Ex. 1002 ¶ 148). Petitioner contends that Gupta teaches using a hydrogen containing diluent gas to reduce the cathode deposits because hydrogen will preferentially react with the free fluorine over the tungsten. *See id.* at 48–49 (citing Ex. 1008 ¶ 41; Ex. 1002 ¶¶ 148–149). Petitioner asserts that Gupta also teaches that using a hydrogen containing diluent gas that does not have the dopant species can lead to a reduction in beam current, and proposes using a co-species with a dopant gas to counteract a reduction in beam current. *See id.* at 49 (citing Ex. 1008 ¶ 45; Ex. 1002 ¶ 150). Thus, Petitioner contends that Gupta specifically discloses the use and benefits of using both a halide (e.g., GeF_4) and hydride (e.g., GeH_4) of the same dopant species to achieve extended source life without a drop in beam current. *See id.* (citing Ex. 1008 ¶¶ 46–47; Ex. 1002 ¶ 150).

Petitioner asserts that a person of ordinary skill in the art “would have further looked for ways to further extend source lifetime of such processes and would have combined the teachings of *Rendon* and *Trace* with *Gupta* to develop an ion implantation process that used isotopically enriched compounds as the dopant gas along with diluent and co-species gases.” Pet. 47 (citing Ex. 1002 ¶¶ 149–156); *see id.* at 49 (citing Ex. 1002 ¶¶ 149–156), *id.* at 57 (citing Ex. 1002 ¶¶ 149–156), *id.* at 62 (citing Ex. 1002 ¶¶ 149–

156). On the foregoing bases, Petitioner sets forth sufficient articulated reasoning with rational underpinning to establish that one of ordinary skill in the art would have modified the combined teachings of Rendon, Trace, and Gupta, with Gupta's teachings to include diluent and co-species gases. See Pet. 47–50, 54–55; *KSR*, 550 U.S. at 418 (quoting *Kahn*, 441 F.3d at 988).

Turning to the “with the proviso” conditional limitations of claim 1 and independent claim 15, discussed above in Section II.A, Petitioner acknowledges implicitly that Rendon does not teach or suggest the $^{72}\text{GeF}_4$ dopant is “isotopically enriched [to a] level [] greater than 51.6 % for the mass 72 germanium isotope.” See Pet. 50–51. Petitioner relies on Trace for teaching the $^{72}\text{GeF}_4$ dopant composition is enriched to a level greater than 51.6%, namely 85–99+% in ^{72}Ge . See *id.* at 50 (citing Ex. 1009, 1). Petitioner's aforementioned citations also address sufficiently the limitations of dependent claims 7 and 16, which recite “one or more germanium compounds isotopically enriched above natural abundance level of at least one germanium isotope of mass . . . 72” See *id.* at 56–57 (citing, *inter alia*, Ex. 1006, 707, 709; Ex. 1009, 1; Ex. 1002 ¶¶ 149–156; incorporating by reference Pet. 54–55), *id.* at 62 (citing, *inter alia*, Ex. 1006, 707, 709; Ex. 1009, 1; Ex. 1002 ¶¶ 149–156; incorporating by reference Pet. 56–57). Likewise, the aforementioned citations also address sufficiently the limitations of dependent claims 9, 13, 17, and 18, which recite at least “isotopically enriched germanium tetrafluoride” and at least “germanium tetrafluoride.” See *id.* at 57 (citing, *inter alia*, Ex. 1006, 707, 709; Ex. 1009, 1; Ex. 1002 ¶¶ 149–156; incorporating by reference Pet. 54–55), *id.* at 59 (citing Ex. 1006, 707; Ex. 1008 ¶ 10; Ex. 1002 ¶¶ 149–150, 152–155), *id.* at

62 (citing, *inter alia*, Ex. 1006, 707, 709; Ex. 1008 ¶ 10, 17; Ex. 1009, 1; incorporating by reference Pet. 59, 62).

Turning to Petitioner's reasons to combine the teachings of the references, Petitioner asserts that Rendon teaches that using isotopically enriched ^{72}Ge to more than 50% abundance is a viable solution to avoid the known arsenic cross-contamination issue while obtaining a slight increase in throughput, and increasing beam current. *See* Pet. 48 (citing Ex. 1006, 707, 709; Ex. 1002 ¶¶ 143–144). Petitioner contends Trace teaches that its commercially available isotopically GeF_4 dopant gas source, isotopically enriched in ^{72}Ge to 82–98+% abundance, includes the same type of enriched gas source contemplated by Rendon to overcome the deficiencies of natural ^{74}Ge implants. *See id.* at 50 (citing Ex. 1006, 710; Ex. 1009, 1, 2; Ex. 1002 ¶ 146). Petitioner asserts that a person of ordinary skill in the art “considering *Rendon* would have been motivated to incorporate the teachings of *Trace* to develop an ion implantation process that used commercially-available, isotopically enriched compounds, including ^{72}Ge , to extend the ion source lifetime and reduce arsenic contamination.” *Id.* at 47 (citing Ex. 1002 ¶¶ 149–156). Petitioner contends a person of ordinary skill in the art

would have used simple substitution of the isotopically enriched ^{72}Ge at [greater than] 51.6% abundance in *Trace* (already taught for use in ion implantation), and replace the 51.6% isotopically enriched ^{72}Ge in *Rendon* to extend ion source life by decreasing the amount of tungsten that builds up on the cathode, and reduce arsenic cross-contamination by implanting ^{72}Ge .

Pet. 51 (citing Ex. 1002 ¶ 153); *see id.* at 53 (citing Ex. 1002 ¶¶ 145–147). On the foregoing bases, Petitioner sets forth sufficient articulated reasoning with rational underpinning to establish that one of ordinary skill in the art

would have modified the combined teachings of Rendon, Trace, and Gupta, with Trace's teachings to utilize isotopically enriched $^{72}\text{GeF}_4$ enriched to 82–98+%. See *KSR*, 550 U.S. at 418 (quoting *Kahn*, 441 F.3d at 988).

Patent Owner does not contest Petitioner's factual assertions and articulated reasons to combine the teachings of the references regarding claims 1, 2, 4, 6, 7, 9, 12, 13, and 15–19. See PO Resp. 1–48. Patent Owner also does not offer objective indicia of nonobviousness regarding claims 1, 2, 4, 6, 7, 9, 12, 13, and 15–19. See *id.*

Accordingly, based on the record before us, we are persuaded by a preponderance of the evidence that Petitioner establishes that claim 1, claims 2, 4, 6, 7, 9, 12, and 13, dependent therefrom, independent claim 15, and claims 16–19 dependent therefrom, are unpatentable over Rendon, Trace, and Gupta.

c. Analysis of Dependent Claims 14 and 20

In addition to Petitioner's factual assertions and articulated reasons to combine the teachings of the references discussed immediately above in Section II.D.3.b., Petitioner contends that the combined teachings of Rendon, Trace, and Gupta render obvious “germane and isotopically enriched germanium tetrafluoride” dopant gas formulation or composition recited alternatively in Markush group (ii) of claims 14 and 20. See Pet. 59–60, 63; see also Pet. 47–52 (discussing reasons to combine teachings of the references). Petitioner contends that Rendon and Gupta teach the use of GeF_4 as a dopant gas, and Rendon and Trace teach the use of isotopically enriched GeF_4 enriched in ^{72}Ge . See Pet. 59 (citing Ex. 1006, 707, 709; Ex. 1009, 1; Ex. 1008 ¶ 10). Petitioner asserts that “Gupta . . . discloses the benefits of using a dopant gas along with a co-species gas, for example,

GeF₄ along with GeH₄.” Pet. 59–60 (citing Ex. 1008, Abstract ¶¶ 17, 21–22, 46; Ex. 1002 ¶ 150), *id.* at 63 (citing Ex. 1006, 707; Ex. 1008 ¶¶ 10, 17, 21, 22, 38, 40; incorporating by reference Pet. 59–60). More specifically, Petitioner asserts that Gupta teaches using GeF₄ as the dopant species with GeH₄ as a co-species to achieve extended source life without a drop in beam current. *See id.* at 49 (citing Ex. 1008 ¶¶ 46–47; Ex. 1002 ¶ 150).

Petitioner contends that a person of ordinary skill in the art “would have found it obvious to combine the teachings from Rendon and Trace regarding isotopically enriched GeF₄ enriched in ⁷²Ge with the use of any combination of the diluent gases or co-species gases discussed in Gupta.” *Id.* at 60 (citing Ex. 1002 ¶¶ 149–156). More specifically, Petitioner asserts that a person of ordinary skill in the art

would have looked for ways to further extend [ion] source lifetime of such [ion implantation] processes without reducing beam current and would have combined the teachings of *Rendon* regarding the use of isotopically enriched ⁷²Ge with *Gupta* to develop an ion implantation process that used isotopically enriched compounds as the dopant gas along with diluent and co-species gases. (Ex. 1002, ¶¶ 149–156). This is especially relevant given the explicit disclosure in *Gupta* of using GeF₄ as the dopant gas and GeH₄ as the co-species gas, and the benefits discussed in *Rendon* of using isotopically enriched GeF₄. (Ex. 1002, ¶¶ 150).

Id. at 49. On the foregoing bases, Petitioner has shown persuasively, with sufficient supporting evidence, that the combination of Rendon, Trace, and Gupta teaches or suggests the dopant gas formulation or composition “germane and isotopically enriched germanium tetrafluoride” recited in Markush group (ii) of claims 14 and 20. Petitioner has further provided sufficient articulated reasoning with rational underpinning to establish that

one of ordinary skill in the art would have modified the combined teachings of Rendon, Trace, and Gupta, in view of Gupta's teachings of using germane as a co-species gas for germanium tetrafluoride. *See KSR*, 550 U.S. at 418 (quoting *Kahn*, 441 F.3d at 988).

Patent Owner argues that claims "14 and 20 are non-obvious over Rendon, Trace, and Gupta for at least the same reasons as discussed above regarding [unpatentability over Rendon, ATMI VAC, and Gupta]." PO Resp. 40–41 (citing Ex. 2008 ¶¶ 57, 105). Patent Owner alleges that Trace fails to make up for the deficiencies of Rendon and Gupta discussed by Patent Owner when addressing unpatentability over Rendon, ATMI VAC, and Gupta. *See id.* at 40. Patent Owner also asserts that objective indicia of non-obviousness point to a finding of nonobviousness. *See id.* For the same reasons as those discussed above in Section II.D.1.e. addressing unpatentability of claims 14 and 20, Patent Owner's arguments are not persuasive and the evidence supporting obviousness outweighs Patent Owner's evidence of nonobviousness, including objective indicia of nonobviousness.

Accordingly, we are persuaded by a preponderance of the evidence that claims 14 and 20 are unpatentable over Rendon, Trace, and Gupta.

d. Analysis of Dependent Claim 11

In addition to Petitioner's factual assertions, and articulated reasons to combine the teachings of the references discussed above in Sections II.D.3.b. and II.D.3.c., Petitioner contends that "*Rendon* specifically discloses using a diluent gas such as argon or nitrogen, along with the dopant gas GeF₄," and "*Gupta* discloses using a dopant gas along with a supplemental gas, where the supplemental gas could include a diluent gas."

Pet. 54 (citing Ex. 1006, 707; Ex. 1008 ¶¶ 17, 21, 22, 46; Ex. 1002 ¶¶ 149–156); *see id.* at 57–58 (citing Ex. 1006, 707; Ex. 1008 ¶¶ 38, 40; Ex. 1002 ¶¶ 149–156; incorporating by reference Pet. 54–55); *see* Reply 9–10 (citing Ex. 1006, 707; Ex. 1008 ¶¶ 15, 40); *see also* Ex. 1008 ¶¶ 38, 40 (teaching argon, xenon, hydrogen, and fluorine).

Petitioner contends that a person of ordinary skill in the art “reading *Rendon* in view of *Trace* and *Gupta* would have seen the benefits to extended ion source lifetime, increased throughput and reduced arsenic cross-contamination with usage of isotopically enriched ^{72}Ge , as disclosed in *Rendon* and *Trace*, and would have understood that including a supplemental gas, as disclosed in *Gupta*, would further extend the ion source lifetime.” *Id.* at 57 (citing Ex. 1002 ¶¶ 149–156); *see id.* at 60 (citing Ex. 1002 ¶¶ 149–156). On the foregoing bases, Petitioner has shown persuasively, with sufficient supporting evidence, that the combination of *Rendon*, *Trace*, and *Gupta* teaches or suggests at least one of the supplemental gases recited in claim 11, and has provided sufficient articulated reasoning with rational underpinning to establish that one of ordinary skill in the art would have modified the combined teachings of *Rendon*, *Trace*, and *Gupta*, in view of *Gupta*’s teachings of using a diluent gas. *See KSR*, 550 U.S. at 418 (quoting *Kahn*, 441 F.3d at 988).

Patent Owner contends that claim 11 is “non-obvious over *Rendon*, *Trace*, and *Gupta* for at least the same reasons as discussed above regarding [unpatentability over *Rendon*, *ATMI VAC*, and *Gupta*].” PO Resp. 40–41 (citing Ex. 2008 ¶¶ 57, 105). Patent Owner asserts that *Trace* fails to make up for the deficiencies of *Rendon* and *Gupta* discussed by Patent Owner addressing unpatentability over *Rendon*, *ATMI VAC*, and *Gupta*. *See id.* at

40. For the same reasons as those discussed above in Section II.D.1.f. addressing unpatentability of claim 11, we do not agree with Patent Owner's arguments.

Accordingly, we are persuaded by a preponderance of the evidence that claim 11 is unpatentable over Rendon, Trace, and Gupta.

4. *§ 103 Unpatentability of Claims 3, 5, 8, and 10 over Rendon, Trace, Gupta, and Tempel*

Petitioner relies on many of the same combined teachings of Rendon, Trace, and Gupta, as discussed above in Section II.D.3.b. through II.D.3.d. addressing dependent claims 3, 5, 8, and 10. *Compare* Pet. 64–67, with Pet. 47–63. Petitioner acknowledges implicitly that the combination of Rendon, Trace, and Gupta, does not teach or suggest compositions that comprise isotopically enriched germane, as required by claims 3 and 8, or that comprise isotopically enriched germane and isotopically enriched germanium tetrafluoride, as required by claims 5 and 10. *See* Pet. 64–67. Petitioner asserts that Tempel is directed to an ionic gas used in ion implant processes and specifically teaches the use of germane, germanium tetrafluoride, isotopically-enriched analogs, and mixtures thereof. *See id.* at 64 (citing Ex. 1010 ¶ 11), *id.* at 66 (quoting Ex. 1010 ¶ 6, citing Ex. 1002 ¶ 159). Petitioner contends, “*Tempel* discloses the use of isotopically enriched GeH₄ as the dopant gas, and it discloses the use of isotopically enriched GeH₄ in combination with isotopically enriched GeF₄.” *Id.* at 64 (citing Ex. 1010 ¶ 6; Ex. 1002 ¶ 159); *see id.* at 66 citing Ex. 1010 ¶ 6; Ex. 1002 ¶ 159).

Petitioner contends that it would have been obvious to modify the combined teachings of Rendon, Trace, and Gupta with Tempel's teachings

of using isotopically enriched germane and isotopically enriched germanium tetrafluoride. See Pet. 64–67 (citing Ex. 1002 ¶¶ 158–162). Petitioner asserts that a person of ordinary skill in the art “would have looked for ways to further increase source lifetime of such processes and would have combined the teachings of *Tempel* with *Rendon* and *Gupta* to devise an ion implantation process that used isotopically enriched co-species gases in combination with isotopically enriched dopant gases, or isotopically enriched either the co-species or the dopant gas.” *Id.* at 43–44 (citing Ex. 1002 ¶ 138); see *id.* at 65 (citing Ex. 1002 ¶ 160). Petitioner also contends that a person of ordinary skill in the art would have recognized that the benefits of using isotopically enriched gases discussed in *Rendon* and *Trace* would be applicable to other isotopically enriched gases besides GeF_4 , and would understand that isotopically enriching GeH_4 would result in similar benefits as enriching GeF_4 . See *id.* at 65–66 (citing Ex. 1002 ¶¶ 161–162). On the foregoing bases, Petitioner has shown persuasively, with sufficient supporting evidence, that the combination of *Rendon*, *Trace*, *Gupta*, and *Tempel* teaches or suggests the limitations recited in claims 3, 5, 8, and 10, and has provided sufficient articulated reasoning with rational underpinning to establish that one of ordinary skill in the art would have modified the combined teachings of *Rendon*, *Trace*, and *Gupta*, in view of *Tempel*’s teachings of using isotopically enriched germanium tetrafluoride (GeF_4) and isotopically enriched germane (GeH_4). See *KSR*, 550 U.S. at 418 (quoting *Kahn*, 441 F.3d at 988).

Patent Owner contends that claims 3, 5, 8, and 10 are “non-obvious over *Rendon* in view of *Trace*, *Gupta*, and *Tempel* for at least the same reasons as discussed in [the Petition at pages 30–40] addressing

[unpatentability over Rendon, ATMI VAC, Gupta, and Tempel].” PO Resp. 41 (citing Ex. 2008 ¶¶ 57, 106). Patent Owner asserts that Trace fails to make up for the deficiencies of Rendon, Gupta, and Tempel as discussed by Patent Owner addressing unpatentability over Rendon, ATMI VAC, Gupta, and Tempel. *See id.* For the same reasons as those discussed above in Section II.D.2.b. addressing unpatentability of claims 3, 5, 8, and 10, we do not agree with Patent Owner’s arguments.

Accordingly, we are persuaded by a preponderance of the evidence that claims 3, 5, 8, and 10 are unpatentable over Rendon, Trace, Gupta, and Tempel.

5. Weight of Petitioner’s Declarant Dr. Sinha’s Testimony

Patent Owner asserts that Dr. Sinha’s testimony regarding the patentability of the claims should be given no weight because Dr. Sinha is a paid employee of Petitioner and has a clear bias and self-interest in this proceeding. *See* PO Resp. 42. Patent Owner contends that in assessing the probative values of an expert opinion, the Board must consider three factors including the interest of the expert in the outcome of the case. *See id.* (citing *EC Data Sys. Inc., v. J2 Global, Inc.* Appeal 2014-008203, slip op. at 8 (PTAB Dec. 15, 2014); *Ex Parte Magna Elecs., Inc.*, Appeal 2013-004164, slip op. at 5 (PTAB May 28, 2014)). Patent Owner contends that the probative weight of Dr. Sinha’s testimony is diminished by his substantial interest in the outcome of the case. *See id.*

Patent Owner asserts that Dr. Sinha is biased because, in the 2012 conference poster, he praised the dopant compositions of claims 14 and 20 that he now asserts are obvious. *See* PO Resp. 42. Patent Owner asserts that, Dr. Sinha failed to list the 2012 conference poster that contradicts his

declaration in the list of publications or presentations of his curriculum vitae (CV) and gave multiple answers when asked about the relevance of the 2012 conference poster to parts (i) and (iv) of claims 14 and 20. *See id.* at 42–45 (quoting Ex 2009, 168:14–169:8, 170:16–171:1; citing Ex. 1003). Patent Owner further contends that Dr. Sinha is biased because he did not study in depth the prior art references he relied upon. *See id.* at 45. Patent Owner reasons that he could not answer questions about the Tempel reference that did not relate to paragraph 6, the portion of Tempel that he used for his analysis. *See id.* Patent Owner asserts that Dr. Sinha’s opinions were based on an incorrect understanding of key concepts, such as dopant gas or whether any ions must be implanted into a substrate to fall within the bounds of an ion implantation process. *See id.* at 45–46 (quoting Ex. 1002 ¶ 87; Ex. 2009, 31:8–15; citing Ex. 2008 ¶ 48; Ex. 2009, 23:3–25:6, 29:12–33:22, 134:15–135:6).

In response, Petitioner asserts that the evidence does not show that Dr. Sinha has, or ever has had, a stake in the outcome of this proceeding. *See* Reply 26. Petitioner further argues that Patent Owner does not substantively challenge any of Dr. Sinha’s opinions. *See id.* Petitioner contends that Dr. Sinha explained the protocol used to include publications but not posters in his curriculum vitae (CV). *See id.* (citing Ex. 2009, 168:14–169:1). Lastly, Petitioner contends that Patent Owner’s failure to provide the Board with the second 2014 conference poster (Ex. 1027), which undermines Patent Owner’s position on unexpected results, shows that Dr. Sinha’s omission of the 2012 conference poster (Ex. 2003/Ex. 1025) from his list of publications or presentations was not content-based or selective. *See id.*

We are not persuaded that the probative weight of Dr. Sinha's testimony is diminished based solely on Patent Owner's arguments alleging Dr. Sinha is biased and has a substantial interest in the outcome of these proceedings. To assess the probative value of an expert opinion, we must consider the following factors: (1) the interest of the expert in the outcome of the case; (2) the presence or absence of factual evidence supporting the expert's opinion, and (3) the strength of any opposing evidence. *See Ashland Oil, Inc. v. Delta Resins & Refractories, Inc.*, 776 F.2d 281, 294–295 (Fed. Cir. 1985).¹⁵ Although “the opinion testimony of a party having a direct interest in the pending [proceeding] is less persuasive than opinion testimony by a disinterested party, it cannot be disregarded for that reason alone and may be relied upon when sufficiently [persuasive].” *Id.*

First, we are not persuaded that Patent Owner's attorney arguments that Dr. Sinha is biased because he could not answer questions about the Tempel reference, and characterization that Dr. Sinha had an incorrect understanding of the meaning of dopant gas and whether any ions must be implanted into a substrate to fall within the bounds of an ion implantation process. We also are not persuaded that Dr. Sinha is biased and has an interest in the proceeding because he failed to include the 2012 conference poster (Ex. 2003/Ex. 1025) in his CV. As pointed out by Petitioner, Dr. Sinha explained why the 2012 conference poster was not included in his CV. *See* Ex. 2009, 168:14–169:1. Moreover, the 2014 conference poster (Ex.

¹⁵ An additional factor for consideration is “the nature of the matter sought to be established,” which is, here, obviousness. *Ashland Oil*, 776 F.2d at 294.

2005/Ex. 1026) and second 2014 conference poster (Ex. 1027), also were not included in Dr. Sinha's CV, which supports Petitioner's contention that the omission of the 2012 conference poster was not content-based or selective. *See* Ex. 1003, 3–4.

Patent Owner also does not challenge the factual evidence supporting Dr. Sinha's opinions that the invention recited in claims 3, 5, 8, 10, 11, 14, and 20 would have been obvious. As to the remaining factor, we also consider the weakness, as discussed above in Sections II.D.1.e, II.D.1.f, and II.D.2.b., of Patent Owner's evidence offered to support nonobviousness and opposing Dr. Sinha's opinions, supported by factual evidence, that the invention of claims 3, 5, 8, 10, 11, 14, and 20 would have been obvious.

For the foregoing reasons we are not persuaded by Patent Owner's arguments that Dr. Sinha's testimony has diminished probative value and should be given no weight.

6. *Constitutionality of Inter Partes Review*

Patent Owner argues that the Petition should be rejected because the proceeding violates Patent Owner's constitutional rights under Article III and the Seventh Amendment of the U.S. Constitution. *See* PO Resp. 47. (citing U.S. CONST. amend. VII; *Markman v. Westview Instruments, Inc.*, 517 U.S. 370, 377 (1996); *McCormick Harvesting Mach. Co. v. Autlman & Co.*, 169 U.S. 606, 609 (1898)). Patent Owner acknowledges that the Supreme Court granted certiorari in *Oil States Energy Servcs. LLC v. Greene's Energy Grp., LLC*, No. 16-712, 137 S. Ct. 2239 (2017) to consider the constitutionality of *inter partes* reviews. *See* PO Resp. 47. Patent Owner seeks to preserve this issue pending the outcome in *Oil States*. *See id.*

At this time, no court has found *inter partes* review unconstitutional, and we are bound by Federal Circuit precedent. *See MCM Portfolio LLC v. Hewlett-Packard Co.*, 812 F.3d 1284 (Fed. Cir. 2015), *cert. denied*, 137 S. Ct. 292 (2016). The matter is before the U.S. Supreme Court, and Patent Owner's arguments on this basis are premature.

III. CONCLUSION

Petitioner has shown by a preponderance of the evidence that claims 1– 20 are unpatentable under 35 U.S.C. § 103.

IV. ORDER

In consideration of the foregoing, it is hereby:

ORDERED that claims 1, 2, 4, 6, 7, 9, and 11–20 have been shown to be unpatentable under 35 U.S.C. § 103 as obvious over Rendon, ATMI VAC, and Gupta;

FURTHER ORDERED that claims 3, 5, 8, and 10 have been shown to be unpatentable under 35 U.S.C. § 103 as obvious over Rendon, ATMI VAC, Gupta, and Tempel;

FURTHER ORDERED that claims 1, 2, 4, 6, 7, 9, and 11–20 have been shown to be unpatentable under 35 U.S.C. § 103 as obvious over Rendon, Trace, and Gupta;

FURTHER ORDERED that claims 3, 5, 8, and 10 have been shown to be unpatentable under 35 U.S.C. § 103 as obvious over Rendon, Trace, Gupta, and Tempel; 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.

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