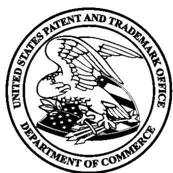

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/263,869	09/13/2016	Soumendra Narayan BARMAN	023149USA	1935

44257 7590 08/19/2020

PATTERSON & SHERIDAN, LLP - - APPLIED MATERIALS
24 GREENWAY PLAZA
SUITE 1600
HOUSTON, TX 77046

EXAMINER	
TUROCY, DAVID P	

ART UNIT	PAPER NUMBER
1718	

NOTIFICATION DATE	DELIVERY MODE
08/19/2020	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

Pair_Eofficeaction@pattersonsheridan.com
psdocketing@pattersonsheridan.com

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Ex parte SOUMENDRA NARAYAN BARMAN, JIAN J. CHEN, PRAKET P. JHA, BOK HOEN KIM, and MIGUEL S. FUNG

Appeal 2019-005594
Application 15/263,869
Technology Center 1700

Before ROMULO H. DELMENDO, KAREN M. HASTINGS, and DEBRA L. DENNETT, *Administrative Patent Judges*.

DELMENDO, *Administrative Patent Judge*.

DECISION ON APPEAL

The Appellant[1] appeals under 35 U.S.C. § 134(a) from the Primary Examiner's final decision to reject claims 11, 12, and 16–20.[2] We have jurisdiction under 35 U.S.C. § 6(b).

We affirm.

---

[1] We use the word "Appellant" to refer to "applicant" as defined in 37 C.F.R. § 1.42—i.e., "Applied Materials, Inc." (Application Data Sheet filed September 13, 2016 at 6), which is also identified as the real party in interest (Appeal Brief filed March 27, 2019 ("Appeal Br.") at 3).

[2] *See* Appeal Br. 6–8; Reply Brief filed July 15, 2019 ("Reply Br.") at 2–3; Final Office Action entered July 12, 2018 ("Final Act.") at 3–14; Examiner's Answer entered May 13, 2019 ("Ans.") at 3–14.

I. BACKGROUND

The subject matter on appeal relates to a method for forming a silicon nitride layer (Specification filed September 13, 2016 ("Spec.") ¶ 2). Representative claim 16, which was amended after final rejection to incorporate the limitations of canceled claim 15 (Ans. 3; Appeal Br. 8), is reproduced from the Claims Appendix to the Appeal Brief, as follows:

> 16. A method for forming a silicon nitride layer, comprising:
>
> flowing a gas mixture into a processing chamber, the gas mixture comprising trisilylamine and a nitrogen-containing precursor other than the trisilylamine;
>
> forming activated species of the trisilylamine and the nitrogen-containing precursor *by pulsing radio frequency power into the processing chamber while the gas mixture is flowing into the processing chamber* at a chamber pressure ranging from about 1 mtorr to about 15 mtorr, wherein the radio frequency power has a power ranging from about 25 W to about 300 W, the pulsed radio frequency power having a duty cycle ranging from about 5 percent to about 30 percent; and
>
> reacting the activated species of the trisilylamine and the nitrogen-containing precursor to form a reaction product on a substrate disposed in the processing chamber, the substrate having a temperature of less than 300 degrees Celsius.

(Appeal Br. 10 (emphasis added)).

II. REJECTION ON APPEAL

Claims 11, 12, and 16–20 stand rejected under 35 U.S.C. § 103 as unpatentable over Lee et al.[3] ("Lee") in view of Hausmann et al.[4]

---

[3] US 2010/0184302 A1, published July 22, 2010.

[4] US 2010/0099271 A1, published April 22, 2010.

(“Hausmann ’271”) and further in view of Hausmann et al.[5] (“Hausmann ’854”).

III. DISCUSSION

1. *Grouping of Claims*

Although the Appellant provides arguments under a separate sub-heading for claim 15, which has been canceled and incorporated into independent claim 16 (Appeal Br. 8), claims 11, 12, and 16–20 are argued together (*id.* at 6–7). Therefore, we decide this appeal on the basis of independent claim 16, which we designate as representative pursuant to 37 C.F.R. § 41.37(c)(1)(iv). By this rule, claims 11, 12, and 17–20 stand or fall with claim 16.

2. *The Examiner’s Position*

The Examiner finds that Lee describes a method for forming a conformal silicon nitride layer on a semiconductor substrate comprising the same steps recited in claim 16 except Lee does not disclose pulsing the plasma power to about 25 W to about 300 W (Ans. 3–4, 6–8). Regarding pulsing the power, the Examiner finds that Hausmann ’271 teaches pulsing the plasma power in a PECVD (plasma enhanced chemical vapor deposition) process to achieve enhanced control—i.e., more control to form silicon-based dielectric films that are thinner and more conformal than those produced by conventional PECVD, efficiency, and product quality (*id.* at 4–5). Based on Hausmann ’271’s teachings, the Examiner concludes that

> it would have been obvious to a person having ordinary skill in the art before the effective filing date of the claimed invention to have modified the process of Lee to have pulsed the RF [radio

[5] US 2013/0189854 A1, published July 25, 2013.

> frequency] plasma power during the deposition of the silicon nitride film because Hausmann ’271 teaches that it will provide enhanced control, efficiency and product quality of the PECVD process to form thinner and more conformal films such that it will provide the desired and predictable result of depositing improved silicon nitride films.

(*Id.* at 5). Regarding the power wattage, the Examiner finds that Hausmann ’854 teaches that suitable plasma power wattages in a silicon nitride deposition process using trisilylamine (TSA) as a silicon-containing precursor and a nitrogen-containing reactant may range from 100 W to 5,000 W (*id.* at 8). Based on Hausmann ’854’s teachings, the Examiner concludes that

> it would have been obvious to a person having ordinary skill in the art before the effective filing date of the claimed invention to have modified the method of Lee in view of Hausmann ’271 to have selected a plasma power ranging from 100 to 5000 W because Hausmann ’854 teaches that such a power is suitable for generating a plasma used to activate a vapor phase reaction involving TSA and a nitrogen-containing reactant such as ammonia such that it will provide the desired and predictable result of providing suitable power to generate a plasma from the processing gas as indicated by Hausmann ’854.

(*Id.* at 8–9).

3. The Appellant’s Contentions

The Appellant contends that a person having ordinary skill in the art would not have combined Lee, which teaches TSA, with Hausmann ’271, because Hausmann ’271 does not disclose TSA as a silicon-containing precursor and, therefore, does not teach or suggest using pulsed plasma with TSA (Appeal Br. 6). According to the Appellant, Hausmann ’271 teaches using pulsed plasma power to solve a specific problem for radicals having “high sticking coefficients,” but activated species of TSA are described in

the current Specification as having "lower sticking coefficients" (*id.*). The Appellant urges that, therefore, these references "do not teach, show, or suggest a method including forming activated species of the trisilylamine and the nitrogen-containing precursor by pulsing radio frequency power into the processing chamber while the gas mixture is flowing into the processing chamber, as recited in claim 16" (*id.* at 7). Regarding Hausmann '854, the Appellant argues that it does not cure the alleged deficiencies in the Examiner's combination of Lee and Hausmann '271, and further that, in Hausmann '854, "a plasma is struck only when the flow [of] TSA reactant is ceased" (*id.* at 8). The Appellant urges that, therefore, Hausmann '854 "does not teach a method including forming activated species of the trisilylamine and the nitrogen-containing precursor by pulsing radio frequency power into the processing chamber while the gas mixture is flowing into the processing chamber" (*id.*).

4. Opinion

For the reasons well-stated in the Examiner's Answer and Final Action, we conclude that the Appellant's arguments fail to identify reversible error in the rejection.[6] We add the following for emphasis.

As the Examiner correctly finds, Lee describes a method for forming a conformal dielectric film having Si–N bonds on a semiconductor substrate by PECVD, wherein the method includes the steps of: introducing a nitrogen- and hydrogen-containing reactive gas and an additive gas into a reaction space in which a semiconductor substrate is placed; applying RF power to the reaction space maintained at pressures and temperatures that

---

[6] *See*, *e.g.*, *In re Jung*, 637 F.3d 1356, 1365 (Fed. Cir. 2011).

overlap those recited in claim 16; and introducing a hydrogen-containing silicon precursor (e.g., TSA) in pulses into the reaction space in which plasma is excited, thereby forming a conformal dielectric film having Si–N bonds on the substrate (Lee ¶¶ 10–11, 20, 35–36; Abstract; Fig. 2b). Although Lee does not disclose pulsing the plasma power to about 25 W to about 300 W, as recited in claim 16, we agree with the Examiner that Hausmann ’271 and Hausmann ’854 bridge this gap.

Specifically, as the Examiner correctly finds, Hausmann ’271 teaches that when the plasma power is pulsed in a PECVD method for forming a silicon-based dielectric film on a semiconductor substrate, control, efficiency, and product quality are enhanced (Hausmann ’271 Abstract). According to Hausmann ’271, pulsing the plasma power provides “a more controllable deposition” and “allows for the production of thin films and films with good conformability (or step coverage) in a single pulsed plasma deposition process operation” (*id.* ¶ 3; *see also id.* ¶ 20). Hausmann ’271 teaches that, “[f]or example, pulsing the high frequency RF plasma power at 500 Hz with a 15% duty cycle dramatically improves the step coverage and decreases the thickness per deposition time for silane-based PECVD films” (*id.* ¶ 35). Although Hausmann ’271 appears to teach that pulsed power may be used for radicals that “are highly reactive with high sticking coefficients” (*id.* ¶ 34), it does not say that activated TSA species have “high sticking coefficients” or that pulsed power would be unsuitable for TSA—activated species of which are characterized in the current Specification as having “lower sticking coefficients” (Spec. ¶ 22). In this regard, we agree with the Examiner (Ans. 12) that the phrase “lower sticking coefficients” is not quantifiable because no standard is provided to determine what would be

considered "lower"—let alone relative to "high sticking coefficients" mentioned in Hausmann '271. In any event, Hausmann '271 explicitly teaches that pulsed power is suitable for "generally the same precursors as used in PECVD performed without pulsing the high frequency RF power (i.e., conventional PECVD)" (Hausmann '271 ¶ 29), which would include silicon-containing precursors such as TSA. Hence, we discern no reversible error in the Examiner's well-articulated reason for combining Lee and Hausmann '271—i.e., that a person having ordinary skill in the art would have been prompted to implement Hausmann '271's pulsed plasma power, while maintaining the gas flows (*id.* ¶¶ 42–44), in Lee's method with a reasonable expectation of achieving "a more controllable deposition" and producing "thin films and films with good conformability (or step coverage) in a single pulsed plasma deposition process operation" (*id.* ¶ 3). *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 417 (2007) ("[I]f 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.").

As for the pulse power, we are not persuaded by the Appellant's attack on Hausmann '854 for the same reasons as stated in the Examiner's Response to Argument section (Ans. 13). Moreover, as the Examiner correctly finds (*id.*), Hausmann '271, for example, would have suggested that the power wattage is a result-effective variable that controls whether a suitable plasma is generated (Hausmann '271 ¶ 40 ("The power and frequency supplied by matching network **506** is sufficient to generate a plasma from the process gas, for example 400-700 W total power.")). Thus,

although Hausmann ’271 provides only an *exemplary* power range of 400–700 W, a person having ordinary skill in the art would have determined—through nothing more than routine experimentation—the full range of suitable wattages, including those within the range recited in claim 16, that would generate a suitable pulsed plasma. *In re Applied Materials, Inc.*, 692 F.3d 1289, 1295 (Fed. Cir. 2012).

Accordingly, we uphold the Examiner’s rejection.

IV. CONCLUSION

In summary:

Claims Rejected	**35 U.S.C. §**	**Reference(s)/Basis**	**Affirmed**	**Reversed**
11, 12, 16–20	103	Lee, Hausmann ’271, Hausmann ’854	11, 12, 16–20	

No time period for taking any subsequent action in connection with this appeal may be extended under 37 C.F.R. § 1.136(a).

AFFIRMED