UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES

Ex parte SUNDAR NARAYANAN and
KRISHNASWAMY RAMKUMAR

Appeal 2008-4017
Application 09/975,257
Technology Center 1700

Decided: November 25, 2008

Before BRADLEY R. GARRIS, PETER F. KRATZ, and
MICHAEL P. COLAIANNI, *Administrative Patent Judges*.

KRATZ, *Administrative Patent Judge*.

DECISION ON APPEAL

This is a decision on an appeal under 35 U.S.C. § 134 from the Examiner's final rejection of claims 1-3, 5-19, and 23. Oral arguments were presented on October 22, 2008. We have jurisdiction pursuant to 35 U.S.C. § 6.

STATEMENT OF THE CASE

Appellants' claimed invention is directed to a method of determining the nitrogen content of a nitrided gate oxide layer on a semiconductor substrate. In the formation of semiconductor devices, it is typical that one or more insulating layers or films made of an insulating material, such as silicon dioxide, are formed on a silicon substrate and a gate electrode formed thereupon (Spec. 1). This insulating layer "is referred to as the gate oxide or gate dielectric" (id). Doping of gate electrodes of MOS (metal- oxide-semiconductor) devices with boron (ion implanting) has been employed to improve device performance (id). However, such implantation can result in boron diffusion into the gate dielectric during downstream processing of the device resulting in possible negative influence on the device performance and degradation of the gate oxide film quality (Spec. 2). Also, it was known to incorporate nitrogen into the gate oxide to reduce or block boron diffusion therein (id). Appellants note that nitrogen doping amounts required are "dictated in part by the thermal cycles to which the device is subjected after deposition and doping of the gate electrode" (Spec. 2-3). While "[t]he nitrogen content of the nitrided gate dielectric layer is … an important variable in determining device performance," the nitrogen content of relatively small thickness films may not be easily or inexpensively measured, according to Appellants (Spec. 3). Thus, Appellants explain that "a need for a method of determining the nitrogen content of nitrided gate oxide layers rapidly and in a manner that can be used for statistical process control of gate oxide deposition processes in semiconductor manufacture" has continued to exist (Spec. 4).

Claim 1 is illustrative and reproduced below:

1. A method of determining the nitrogen content of a nitrided gate oxide layer on a semiconductor substrate comprising;

nitriding a gate oxide layer on a semiconductor substrate using nitric oxide (NO) gas to form the nitrided gate oxide layer on the substrate;

oxidizing the nitrided gate oxide layer on the substrate, wherein the step of oxidizing the nitrided gate oxide layer distances the nitrided gate oxide layer away from the semiconductor substrate;

measuring the thickness of the oxidized nitrided gate oxide layer; optionally calculating the change in thickness of the oxidized nitrided oxide layer; and

determining if the measured thickness or calculated change in thickness of the oxidized nitrided gate exceeds a target thickness value.

The Examiner relies on the following prior art references as evidence in rejecting the appealed claims:

Li	5,862,054	Jan. 19, 1999
Yasushi[1]	JP 2000-311928	Nov. 7, 2000
Bensahel	US 6,372,581	Apr. 16, 2002

Wolf, "Silicon Processing for the VLSI Era, Vol. 1-3: Process Integration", Lattice Press, California (1990-2000), pp. 309-310 (vol. 1), 397-398 (vol. 2)

Appellants rely on the following additional evidence in rebuttal:

[1] Appellants and the Examiner refer to Japan Patent Publication No. 2000-311928 as Yasushi, albeit the named inventor of this Japanese Patent Application Publication is Hiroshi Iwata according to the English language translation by the McElroy Translation Company (June 2007) that is of record. Our references to Iwata in this Decision are to the aforementioned English language translation of the Japan Patent Publication No. 2000-311928 rather than the JPO English language computer translation, which latter translation is also of record.

Gusev et al. (Gusev), "Growth and characterization of ultrathin nitrided silicon oxide films," IBM J. Res Develop. 43: 265-86 (May 1999).[2]

Claims 1, 3, 5-12, 17, and 18 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Iwata (JP 2000-311928) in view of Bensahel. Claims 2 and 3-16 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Iwata in view of Bensahel, and Wolf. Claim 19 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Li in view of Iwata and Bensahel. Claim 23 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Li in view of Iwata, Bensahel, and Wolf.

We affirm the Examiner's obviousness rejections for substantially the reasons presented in the Examiner's Answer and as further explained below.

OBVIOUSNESS REJECTION OVER IWATA AND BENSAHEL

Starting with the Examiner's first stated rejection, we note that Appellants argue the rejected claims 1, 3, 5-12, 17, and 18 together as a group in the opening Appeal Brief. Accordingly, we select claim 1 as the representative claim on which we shall focus with respect to deciding this appeal as to the first stated rejection. In so doing, we agree with the Examiner's obviousness determination with respect to representative claim 1.

Appellants argue that Bensahel would not have motivated one of ordinary skill in the art to employ NO gas rather than N_2O gas as the nitriding agent in Iwata but rather would have led one of ordinary skill in the art away from the claimed method (App. Br. 9-10). Moreover, Appellants

[2] Evidence Appendix, Item C; App. Br. 10-11; IDS filed July 03, 2002, Reference AI (see Non-final Office action (Mail Date March 27, 2003)).

argue that Gusev's teachings would have led one of ordinary skill in the art to expect non-equivalent results when using NO rather than N_2O and would not have imparted knowledge to one of ordinary skill in the art of the claim 1 requirement for the occurrence of distancing of the nitrided layer from the substrate as a result of the step of oxidizing the nitrided gate oxide layer (App. Br. 10-16). Based on these contentions, Appellants maintain that the Examiner's proposed combination of references would not have collectively taught or suggested a process corresponding to the representative claim 1 process to one of ordinary skill in the art at the time of the invention (App. Br. 9-16; Reply Br. 1-4).

ISSUES

Have Appellants established reversible error in the Examiner's obviousness rejection of representative claim 1 based on the aforementioned contentions respecting the alleged teaching away from the use of NO as the nitriding agent in Iwata as a replacement for or in addition to N_2O as the nitriding agent and/or by the argument that the re-oxidation step of such a modified process of Iwata would not result in distancing of the nitrided gate oxide layer from the substrate, as called for in representative claim 1?

PRINCIPLES OF LAW

Under 35 U.S.C. § 103, the factual inquiry into obviousness requires a determination of: (1) the scope and content of the prior art; (2) the differences between the claimed subject matter and the prior art; (3) the level of ordinary skill in the art; and (4) any secondary considerations. *Graham v. John Deere Co.*, 383 U.S. 1, 17-18 (1966). "[A]nalysis [of whether the subject matter of a claim is obvious] 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 Int'l Co. Teleflex, Inc.*, 127 S. Ct. 1727, 1741 (2007). *See Okajima v. Bourdeau,* 261 F.3d 1350, 1355 (Fed. Cir. 2001) ("[T]he absence of specific findings on the level of skill in the art does not give rise to reversible error 'where the prior art itself reflects an appropriate level and the need for testimony is not shown").

Moreover, "[t]he motivation need not be found in the references sought to be combined, but may be found in any number of sources, including common knowledge, the prior art as a whole, or the nature of the problem itself."). *DyStar Textilfarben GmBH & Co. Deutschland KG v. C.H. Patrick Co.*, 464 F.3d 1356, 1361 (Fed. Cir. 2006). In this regard, one of ordinary skill in the art is presumed to have skills apart from what the prior art references expressly disclose. *See In re Sovish*, 769 F.2d 738, 742 (Fed. Cir. 1985). "The combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results." *KSR*, 127 S. Ct. at 1739. (Fed. Cir. 2001) .

"As long as some motivation or suggestion to combine the references is provided by the prior art taken as a whole, the law does not require that the references be combined for the reasons contemplated by the inventor." *In re Beattie*, 974 F.2d 1309, 1312 (Fed., Cir. 1992); *see also In re Skoner*, 517 F.2d 947, 950 (CCPA 1975) (explaining that unpatentable subject matter does not become patentable "merely through the employment of descriptive language not chosen by the prior art"); *In re Gershon*, 372 F.2d 535, 539 (CCPA 1967) ("We think it is sufficient that the prior art clearly suggests doing what appellants have done, although an underlying explanation of exactly why this should be done, other than to obtain the expected superior beneficial results, is not taught or suggested in the cited reference."); *Ex parte Obiaya*, 227 USPQ 58, 60 (BPAI 1985) (holding that the recognition of another advantage flowing naturally from following the suggestion of the prior art cannot be the basis for patentability when the difference would otherwise be obvious). Also, *see In re Napier*, 55 F.3d 610, 613 (Fed. Cir. 1995) (inherency arises both in the context of anticipation and obviousness).

A rejection premised upon a proper combination of references cannot be overcome by attacking the references individually. *In re Keller*, 642 F.2d 413, 426 (CCPA 1981). However, s*ee In re Gurley* 27 F.3d 551, 553 (Fed. Cir. 1994) ("A reference may be said to teach away when a person of ordinary skill, upon reading the reference, would be discouraged from following the path set out in the reference, or would be led in a direction divergent from the path that was taken by the applicant."). But, *see In re Bozek*, 416 F.2d 1385, 1390 (CCPA 1969) (reference disclosure must be evaluated for all that it fairly teaches and not only for what is indicated as preferred); *Merck & Co., Inc. v. Biocraft Labs., Inc.*, 874 F.2d 804, 807 (Fed. Cir. 1989) (internal quotations and alterations omitted) (For an obviousness analysis, even the fact that "a specific embodiment is taught to be preferred is not controlling, since all disclosures of the prior art, including unpreferred embodiments, must be considered."). References relied upon by the Appellants may also be relied upon by the PTO in contravention of the Appellants' position. *In re Hedges*, 738 1038, 1041 (Fed. Cir. 1986).

Any arguments not timely raised in the opening brief are considered waived. *See Cross Med. Prods., Inc. v. Medtronic Sofamor Danek, Inc.*, 424 F.3d 1293, 1320-21 n.3 (Fed. Cir. 2005).

RELEVANT FACTUAL FINDINGS

In addition to background factual findings that were made above in setting forth the nature of the subject matter involved in the present appeal and in laying out the rejections and principal issues before us, we find that Iwata is directed to a method of determining the nitrogen content of a nitrided gate oxide layer that can be used in semiconductor manufacturing. Like Appellants' representative claim 1 method and as found by the Examiner, it is not disputed that Iwata discloses or suggests a method of determining gate oxide nitrogen content including steps of: (1) nitriding a gate oxide layer, which oxide layer is formed on a substrate; (2) oxidizing the nitrided gate oxide layer; (3) measuring the thickness of the oxidized nitrided gate oxide layer; and (4) determining or calculating a change in thickness of the oxidized nitrided gate oxide layer (Iwata 3-6; Ans. 4-5). However, Iwata does not describe using NO in the nitriding step but provides an embodiment wherein nitrous oxide (N_2O) is employed at 900 degrees Centigrade. Moreover, Iwata does not explicitly describe that the step of oxidizing the nitrided gate oxide layer results in at least some distancing of the nitrided gate oxide layer away from the substrate as called for in representative claim 1.

Bensahel discloses a process for nitriding a gate oxide layer wherein the nitriding gas can be nitric oxide (NO) using a rapid thermal process (RTP) at relatively high temperature (850 - 900 degrees Centigrade) as disclosed in the prior art referred to therein or at a relatively lower temperature wherein the nitrogen can be more precisely localized at the interface between the substrate and gate oxide interface, both as alternatives to using N_2O (col. 1, ll. 25-65).

Gusev discloses that nitrogen can be incorporated into ultrathin silicon dioxide films by several methods including nitriding with nitrous oxide (N_2O) or nitric oxide (NO) with the optimum nitrogen profile depending on the specific application (pp. 265-266). Gusev further discloses that nitriding with nitrous oxide (N_2O) yields less nitrogen incorporation than nitriding with NO and that nitrous oxide may not be an efficient source of nitrogen for films thinner than about 3nm (pp. 276-278). Gusev further discloses that reoxidation after nitriding with NO can result in a new oxide layer beneath the incorporated oxynitride layer (p. 281).

Appellants acknowledge that film thickness measurements of a gate oxide are performed using "film thickness measurement techniques known in the art" (Spec. 10-11).

ANALYSES

Given the findings of fact set forth above with regard to the prior art use of NO in nitriding gate oxide layers as an alternative to employing N_2O (as evinced by Bensahel), we agree with the Examiner that it would have been prima facie obvious for one of ordinary skill in the art to use NO in place of or in addition to N_2O in the gate oxide nitriding step of Iwata with a reasonable expectation of success in so doing (Ans. 6). After all, Iwata is concerned with determining the nitrogen concentration in the gate oxide film and one of ordinary skill in the art would readily appreciate that Iwata's disclosed nitriding step is not limited to the exemplified embodiment therein, wherein N_2O at a specified temperature is employed for incorporating nitrogen into the gate oxide layer. An ordinarily skilled artisan would have been aware that the use of nitric oxide (NO) was an available option for nitriding of the gate oxide layer of Iwata under substantially similar or different temperature conditions as taught by Bensahel.

Appellants argue that Bensahel would have taught away from and/or not suggested such a substitution based on the teachings therein with respect to a lower temperature nitriding being result effective for a greater localization of the nitrogen near the gate oxide/substrate interface as opposed to a less precise localization when a higher temperature nitriding or rapid thermal process (RTP) with NO is used. However, Appellants have not persuasively articulated why one of ordinary skill in the art would have been discouraged from employing NO in either a lower temperature process or a higher temperature process as the nitriding agent for nitriding the gate oxide of Iwata with the consequent expected nitrogen locating effects in the gate oxide film.

Also, Appellants' have not convincingly explained how Fig. 1(D) of Bensahel suggests that NO nitriding, particularly using a high temperature process as taught by Bensahel to be an available option, would have been discouraged for use in incorporating nitrogen into the gate oxide layer of Iwata (App. Br. 10). In this regard, Appellants' reliance on Gusev in further support of their argument appears misplaced. This is so because Gusev further teaches that NO is an effective nitriding agent for thin gate oxide films and has the added benefit of allowing for greater nitrogen incorporation than using N_2O as the nitrogen source, as noted above.

As for the argued claim 1 requirement for the subsequent oxidation of the nitrided gate oxide layer resulting in a distancing of the nitrided layer away from the substrate, Gusev suggests such an outcome would be expected with re-oxidation of a NO nitrided gate oxide layer, as pointed out in our factual findings above. Rather than supporting Appellants' teaching away and lack of suggestion arguments for the Examiner's proposed modification, Gusev bolsters the Examiner's obviousness position. In particular, Gusev does this by highlighting advantages to be expected from employing nitric oxide as the nitrogen source in terms of both nitrogen incorporation efficacy and by showing that such a NO nitrided gate oxide layer can be distanced from the substrate interface via formation of a new oxide layer beneath the incorporated oxynitride layer (pp. 276-278, and 281). Thus, Appellants' further arguments concerning the Examiner's inherency position as to the claimed distancing effect by using NO as the nitriding agent are not persuasive given the expectation for such distancing that is derived from Appellants' own evidence (Gusev).

As we noted above, Appellants do not present separate arguments specific to any of the commonly rejected claims subject to the Examiner's first stated obviousness rejection in the Appeal Brief. Thus, the commonly rejected claims, including dependent claims 8 and 11, are not subject to separate consideration. *See Cross Med. Prods., Inc. v. Medtronic Sofamor Danek, Inc.*, 424 F.3d 1293, 1320-21 n. 3 (Fed. Cir. 2005). Also, *see* 37 C.F.R. § 41.37(c)(1)(vii) ("When multiple claims subject to the same ground of rejection are argued as a group by appellant, the Board may select a single claim from the group of claims that are argued together to decide the appeal with respect to the group of claims as to the ground of rejection on the basis of the selected claim alone.").

In contrast to their principal Appeal Brief, Appellants' presented separate arguments specifically directed to dependent claims 8 and 11 in the

Reply Brief (Rep. Br. 5). Such a belated change in position does not warrant separate consideration of these dependent claims.

In any event, we observe that Appellants have not persuasively explained how the dependent claim 8 requirement for a thickness measurement of the gate oxide layer before nitration and/or the dependent claim 11 requirement for an initial gate oxide thickness estimation being made from prior collected gate oxide thickness data warrants a separate non-obviousness consideration of either of these claims for reasons stated in the Reply Brief. In this regard, Iwata teaches that techniques for measuring gate oxide thickness are known and Appellants acknowledge they use known techniques as set forth in our factual findings above. Certainly, one of ordinary skill in the art would have recognized that measurements of the gate oxide film thickness before and after subsequent nitrogen incorporation and re-oxidation steps should be performed and data collected for future estimations and process control techniques. After all, an ordinarily skilled artisan is presumed to have some skill and foresight. Hence, if such belated arguments for the separate patentability of dependent claims 8 and 11 were considered to be timely submitted, such arguments are not persuasive of any reversible error in the Examiner's obviousness assessment of the methods required by these claims. "The combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results." *KSR*, 127 S. Ct. at 1739.

CONCLUSION

Appellants have not established reversible error in the Examiner's obviousness rejection of representative claim 1 based on the aforementioned contentions, including the alleged teaching away from using NO as the nitriding agent in Iwata as a replacement for or in addition to N_2O as the nitriding agent and/or by the argument that the re-oxidation step of such a modified process of Iwata would not result in distancing of the nitrided gate oxide layer from the substrate, as called for in representative claim 1.

OTHER OBVIOUSNESS REJECTIONS

Concerning the Examiner's three additional obviousness rejections, all of these rejections are based on the combination of additional prior art references with Iwata and Bensahel. Appellants' arguments for the patentability of these separately rejected claims are premised on the same alleged deficiencies in the combination of Iwata and Bensahel with respect to argued limitations found in claim 1, as we discussed above and found unpersuasive with respect to the first stated obviousness rejection (App. Br. 16-18). It follows that such arguments based on the same limitations are not found persuasive of reversible error in the Examiner's rejection of claims 2 and 3-16 under 35 U.S.C. § 103(a) as being unpatentable over Iwata in view of Bensahel, and Wolf; and in the rejection of claim 19 under 35 U.S.C. § 103(a) as being unpatentable over Li in view of Iwata and Bensahel; and in the rejection of claim 23 under 35 U.S.C. § 103(a) as being unpatentable over Li in view of Iwata, Bensahel, and Wolf.

ORDER

The decision of the Examiner to reject claims 1, 3, 5-12, 17, and 18 under 35 U.S.C. § 103(a) as being unpatentable over Iwata in view of Bensahel; to reject claims 2 and 3-16 under 35 U.S.C. § 103(a) as being unpatentable over Iwata in view of Bensahel, and Wolf; to reject claim 19 under 35 U.S.C. § 103(a) as being unpatentable over Li in view of Iwata and Bensahel; and to reject claim 23 under 35 U.S.C. § 103(a) as being unpatentable over Li in view of Iwata, Bensahel, and Wolf is affirmed.

No time period for taking any subsequent action in connection with this appeal may be extended under 37 C.F.R. § 1.136(a)(1)(iv).

AFFIRMED

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