Paper No. 15

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES

Ex parte TSAI HSIN-CHUAN and LEE PEI-ING

Appeal No. 2000-1587
Application 09/055,254[1]

ON BRIEF

Before THOMAS, FLEMING and SAADAT, Administrative Patent Judges.

SAADAT, Administrative Patent Judge.

DECISION ON APPEAL

This is a decision on appeal from the Examiner's final rejection of claims 1 through 17. Claim 18 has been canceled.

We reverse.

BACKGROUND

Appellants' invention is directed to a process for

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[1] Application for patent filed April 6, 1998, which claims the foreign filing priority benefit under 35 U.S. C. § 119 of Taiwanese Application No. 87100742, filed January 20, 1998.

forming shallow trench isolation in semiconductor integrated circuits, which overcomes the problem of “dishing effect” in the trench areas. Dishing is generally caused by the long time needed to etch back the thicker dielectric layer outside the shallow trench and over-etching of the thinner layer over the trench (specification, page 2). Thin layers of silicon oxide and silicon nitride are formed over a substrate as a hard mask through which shallow trenches are etched into the substrate (specification, page 3). An oxide layer is formed by high density plasma chemical vapor deposition (HDPCVD) to fill in the trenches and cover the substrate. This oxide layer has a higher thickness over larger substrate areas compared to its smaller areas. The HDPCVD oxide layer is covered with a spin-on-glass (SOG) layer and baked before partial etching to remove the SOG outside the trenches (specification, pages 4 & 5). A high-temperature curing of the remaining SOG, which is left in the form of residue over the trench area, further evaporates the solvent and makes the SOG denser and harder. The denser SOG functions as a protection mask for preventing the “dishing effect” in the trench area during the subsequent etching step that removes the remaining oxide layer and the hard mask (specification, pages 5 & 6).

The only independent claim is reproduced as follows:

1. A method for forming shallow trench isolation in a silicon substrate, comprising the steps of:

a. forming a hard mask over said silicon substrate;

b. defining said hard mask and forming a shallow trench by etching;

c. forming an oxide layer to fill said shallow trench and over said hard mask, in which the oxide layer over said hard mask which has smaller area is thinner and the oxide layer over said hard mask which has larger area is thicker;

d. coating a layer of spin-on-glass with suitable thickness control and performing low-temperature baking;

e. partially etching back said spin-on-glass and oxide layer to remove the part outside the shallow trench, wherein said partial etching-back is performed with the recipe whose etching rate to said oxide is higher than that of spin-on-glass;

f. curing said spin-on-glass of which a residue partially remaining over the shallow trench in the larger area serves as a protection mask; and

g. etching back the remaining of said oxide and said spin-on-glass over the hard mask to remove it and taking said hard mask as the end point of etching.

The prior art references of record relied upon by the Examiner in rejecting the appealed claims are:

Lur et al. (Lur)	5,445,989	Aug. 29, 1995
Zheng et al. (Zheng)	5,728,621	Mar. 17, 1998
Perera	5,786,263	Jul. 28, 1998 (filed Apr. 4, 1995)

Stanley Wolf & Richard N. Tauber (Wolf 1), “Silicon Processing for the VLSI Era, Vol. 1: Process Technology,” Lattice Press, p. 184, 1986.

Stanley Wolf (Wolf 2), “Silicon Processing for the VLSI Era, Vol. 2: Process Integration,” Lattice Press, pp. 227, 232 & 238, 1990.

Claims 1 through 17 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Zheng in view of Lur, Perera and Wolf [Wolf 1 and Wolf 2].[2]

Rather than reiterate the conflicting viewpoints advanced

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[2] Claims 1 and 18 were finally rejected under 35 U.S.C. § 112, first paragraph and claims 1 through 18 were finally rejected under 35 U.S.C. § 103 (Paper No. 6, mailed February 24, 1999). Appellants filed an amendment after final rejection (Paper No. 7, filed August 31, 1999) canceling claim 18 and providing arguments to overcome the claim rejections. The Examiner approved entry of this amendment upon filing of a Notice of Appeal and an Appeal Brief in an advisory action (Paper No. 8, mailed September 3, 1999). The Examiner further indicated that the § 112 rejection has been overcome by Appellants’ response.

by the Examiner and Appellants regarding the above-noted rejections, we make reference to the answer (Paper No. 12, mailed November 12, 1999) for the Examiner's complete reasoning in support of the rejections, and to the brief (Paper No. 11, filed October 26, 1999) and the reply brief (Paper No. 13, filed January 12, 2000) for Appellants' arguments thereagainst.

OPINION

In rejecting claims under 35 U.S.C. § 103, the Examiner bears the initial burden of presenting a prima facie case of obviousness. See In re Rijckaert, 9 F.3d 1531, 1532, 28 USPQ2d 1955, 1956 (Fed. Cir. 1993). The conclusion that the claimed subject matter is obvious must be supported by evidence, as shown by some objective teaching in the prior art or by knowledge generally available to one of ordinary skill in the art that would have led that individual to combine the relevant teachings of the references to arrive at the claimed invention. See In re Fine, 837 F.2d 1071, 1074, 5 USPQ2d 1596, 1598 (Fed. Cir. 1988). Furthermore, to reach a conclusion of obviousness under § 103, the examiner must also produce factual basis supported by teaching in a prior art reference or shown to be common knowledge of unquestionable demonstration, consistent with the holding in Graham v. John Deere Co., 383 U.S. 1 (1966). Our reviewing court requires this evidence in order to establish a prima facie case. In re Piasecki, 745 F.2d 1468, 1471-72, 223 USPQ 785, 787-88 (Fed. Cir. 1984); In re Cofer, 354 F.2d 664, 668, 148 USPQ 268, 271-72 (CCPA 1966).

Appellants argue that the Wolf references do not suggest modifying the process of Zheng to have a step of low-temperature baking for the SOG followed by a partial etch back and curing of the SOG. In particular, Appellants assert that Wolf has nothing to do with a partial etch back and does not teach the desirability of modifying the process of Zheng (brief, page 4 and reply brief, page 3). Furthermore, Appellants argue that the Examiner mischaracterizes Zheng's etching selectivity of SOG to the plasma oxide being 1:1 (col. 3, lines 16-18) as the claimed etching back of SOG with an etch rate higher to silicon oxide than SOG (brief, page 5 and reply brief, page 2). Appellants also indicate Zheng and other prior art references fail to teach or suggest the partial etch back as well as the following curing step to convert the remaining SOG to a protection mask (brief, page 5 and reply brief, page 2).

In response to Appellants' arguments, the Examiner argues that "Zheng forms the SOG, partially etches it, and then further etches by CMP" whereas Wolf "describes conventional practice for baking/setting [the] SOG and then baking/curing [it] at a higher temperature" (answer, page 7). The Examiner concludes that Zheng, although silent on curing, "could not complete the CMP step without the conventional practice of baking and curing [of the SOG]" (answer, page 7). With respect to the relative etch rate of oxide and SOG, the Examiner asserts that criticality of this feature was not indicated by Appellants and therefore, any small deviation from the selectivity of 1:1 is routine optimization and meets the claimed limitation (answer, page 8).

Initially, we note that the Examiner indicates the following features as missing in Zheng: how the silicon oxide and silicon nitride layers of the hard mask are formed; the high temperature cure of the SOG and specifying a range for its low temperature baking and the use of ion etching and selectively etching of oxide in relation to that of spin on glass. Among the above-noted features, only curing of the SOG and selectively etching of oxide in relation to that of spin on glass are recited in claim 1, the only independent claim. To simplify the analysis, we initially focus our evaluation of the prior art and claim 1 on these two features.

After a review of Zheng, we find that the reference relates to a process for forming planarized shallow trench isolation in integrated circuits (col. 1, lines 41-43). As the Examiner and Appellants concede, Zheng teaches forming a hard mask over a substrate (Fig. 1 and col. 2, lines 26-30), etching shallow trenches in the substrate (Fig. 2 and Col. 2, lines 37-42) and forming an oxide layer (Fig. 3 and col. 2, lines 43-59). Zheng further teaches coating a layer of SOG (Fig. 4 and col. 2, lines 64-66, col. 3, lines 4 and 5), etching back of SOG and oxide layers (Fig. 5 and col. 3, lines 16-21) and etching back the remaining oxide and SOG layers as well as the hard mask (Fig. 6 and col. 3, lines 22-32). Zheng clearly requires identical etch selectivity for both the oxide and the SOG layers where the remaining oxide and SOG layers are removed using chemical mechanical polishing (CMP) (col. 3, lines 22-25). However, we find that Zheng provides no teaching or suggestion, at any stage of the process, that relates to the claimed step of curing the SOG of which a partially remaining residue over the shallow trench in the larger area serves as a protection mask.

We agree with Appellants that Zheng's relative etching rate during the step of etching back is different from Appellants' claim 1 requiring a higher etching rate for oxide compared to that of SOG. We find that during etching back of oxide and SOG layers, Zheng requires that "the etch selectivity of spin-on-glass to HDP oxide is 1:1" (col. 3, lines 17 and 18), which indicates the same etching rate for both the oxide and the SOG layers. We remain unpersuaded by the Examiner's arguments that the criticality of the higher etching rate or "how high" the "higher" etching rate needs to be are not clearly defined in the disclosure. Appellants clearly require that the etching rate of the oxide be higher than that of the SOG (specification, page 5). We further disagree with the Examiner that changing the etch rate as disclosed by Zheng is routine optimization and obvious since we find that Zheng provides no teaching or suggestion for modifying the 1:1 ratio. Whereas claim 1 requires that the etching back be performed with a recipe having a higher etch rate for the oxide than that of the SOG. This differential etch rate causes most of the thick oxide layer over the hard mask in the larger area be etched away while more of the SOG layer remains over the shallow trench in the larger area as it is etched more slowly (specification, page 5, lines 19-26).

We next review the teachings of Wolf 1 with respect to heating of the low temperature, low density silicon dioxide in order to densify the oxide layer and decrease its etch rate in hydrofluoric acid (HF) solution (page 184). We first observe that the teaching relied upon by the Examiner relates to oxide layers deposited at low temperatures using Chemical Vapor Deposition (CVD), rather than the claimed spin-on-glass (SOG). Additionally, we note that Wolf 1 merely suggests that "[s]ubsequent heating of such [CVD] films to temperatures between 700-1000EC causes *densification*." Therefore, Wolf 1 provides no teachings or suggestion to support "multiple cycling of placing silicon oxide by PECVD and etching for adhesion [that] will create a build up such as by High Density

PECVD," as asserted by the Examiner.

Turning now to Wolf 2, we find that the step of baking the SOG in a low temperature and immediately in a high temperature after it is spun relates to a step of basic SOG process that prevents cracking (page 232). The reference is, however, silent with regard to the step of baking the SOG subsequent to its partial etch back in order to form a protection mask in the large area over the shallow trench. Additionally, the reference teaches that the resist etch rate is sensitive to the cure cycle, whereas the etch rate of the SOG, used in lieu of the resist, is less variable with bake temperature (wolf 2, page 227). Thus, Wolf 2 teaches reduced variation in etch rate when the SOG is cured, which is different from the claimed partially etching back of the SOG and curing its residue over the shallow trench in the large area that serves as a protection mask.

The Court states that "[t]he mere fact that the prior art may be modified in the manner suggested by the Examiner does not make the modification obvious unless the prior art suggested the desirability of the modification." In re Fritch, 972 F.2d 1260, 1266 n.14, 23 USPQ2d 1780, 1783-84 n.14 (Fed. Cir. 1992), citing In re Gordon, 733 F.2d 900, 902, 221 USPQ 1125, 1127 (Fed. Cir. 1984). The court reasons in Para-Ordnance Mfg. Inc. v. SGS Importers Int'l Inc., 73 F.3d 1085, 1088-89, 37 USPQ2d 1237, 1239-40 (Fed. Cir. 1995), that for the determination of obviousness, the court must answer whether one of ordinary skill in the art who sets out to solve the problem and who had before him in his workshop the prior art, would have been reasonably expected to use the solution that is claimed by the Appellants.

The Federal Circuit further states that motivation, suggestion or teaching may come explicitly from statements in the prior art, the knowledge of one of ordinary skill in the art, or, in some cases the nature of the problem to be solved. See In re Dembiczak, 175 F.3d 994, 999, 50 USPQ2d 1614, 1617 (Fed. Cir. 1999). However, "the Board must not only assure that the requisite findings are made, based on evidence of record, but must also explain the reasoning by which the findings are deemed to support the agency's conclusion." In re Lee, 277 F.3d 1338, 1344, 61 USPQ2d 1430, 1434 (Fed. Cir. 2002). The court requires evidence for determination of patentability by clarifying that "common knowledge and common sense," as mentioned in In re Bozek, 416 F.2d 1385, 163 USPQ 545 (CCPA 1969), may only be applied to analysis of the evidence, rather than be a substitute for evidence. In re Lee, 277 F.3d at 1345, 61 USPQ2d at 1435 (Fed. Cir. 2002). See Smiths Industries Medical Systems, Inc. v. Vital Signs, Inc., 183 F.3d 1347, 1356, 51 USPQ2d 1415, 1421 (Fed. Cir. 1999) (Bozek's reference to common knowledge "does not in and of itself make it so" absent evidence of such knowledge).

Based on the findings above, we do not agree with the Examiner that the method of making shallow trench isolation as disclosed by Zheng in combination with the initial bake of the SOG and the densification of the PECVD, as disclosed by Wolf 1 and Wolf 2, would result in the method of claim 1. In that regard, while Zheng requires etching back of the oxide layer and the SOG, the etch selectivity of SOG to the oxide is specified as 1:1 which means equal etch rate instead of the claimed higher etch rate for oxide compared to that of the SOG. Consistent with Appellants' arguments, baking of the SOG as disclosed by Wolf 2 is merely used to "alleviate the problem of resist etch-rate variability" when SOG is used, which has a less variable etch-rate. Additionally, Wolf 2 does not provide for partially etching back of the SOG having an etching rate lower than that of the oxide and subsequently curing the remaining SOG. Rather, the low and high temperature bake of the SOG is performed immediately after it is spun for removing the solvents.

Therefore, we find that Wolf 1 and Wolf 2 neither overcome the deficiencies discussed above with respect to Zheng nor provide any teachings or suggestions to realistically modify Zheng. We also note that Lur pertains to forming trench isolation and specifically teaches the formation of the hard mask by subsequently forming an oxide layer and a nitride layer (col. 3, lines 32-37). Perera, on the other hand forms trench isolation by etching a two-layer oxide layer that fills the trench to leave a trench plug reaching a level above the substrate surface (col. 3, lines 20-22 & 44-47) that is later removed by chemical-mechanical polishing (CMP). Thus, Lur and Perera provide no teaching or suggestion to overcome the deficiencies of Zheng related to partially etching back the SOG with a recipe having a higher etching rate for the oxide and subsequently curing the remaining residue SOG. Accordingly, we do not sustain the rejection of claims 1 through 17 under 35 U.S.C. § 103 over Zheng in view of Lur, Perera and Wolf.

CONCLUSION

In view of the foregoing, the decision of the Examiner rejecting claims 1 through 17 under 35 U.S.C. § 103 is reversed.

REVERSED

JAMES D. THOMAS)
Administrative Patent Judge)
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MICHAEL R. FLEMING Administrative Patent Judge	)	BOARD OF PATENT APPEALS AND INTERFERENCES
	)	
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