

The opinion in support of the decision being entered today was not written for publication and is not binding precedent of the Board.

Paper No. 28

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES

Ex parte TAKAAKI MIYAMOTO

Appeal No. 1998-2916
Application No. 08/606,975

ON BRIEF

Before FLEMING, RUGGIERO and GROSS, Administrative Patent Judges

RUGGIERO, Administrative Patent Judge.

DECISION ON APPEAL

This is a decision on the appeal from the final rejection of claims 1-6 and 8-16, which are the only claims remaining in the application. Claim 7 has been canceled.

The disclosed invention relates to a method of providing a conductive metal layer in a contact hole in an insulating layer on a semiconductor substrate. The contact hole is

filled with an
electrically conductive material after an adhesion layer, and
a
barrier layer in contact with the adhesion layer, are formed
in

the contact hole. The adhesion layer is formed by reducing,
with H₂, a gas of a halogenated product of a group IVB
element, at a flow ratio of 0.4 or greater of group IVB
element to H₂, in an ECR plasma CVD process. Appellant
asserts at page 4 of the specification that the selection of a
flow ratio of 0.4 or greater of group IVB element to H₂ in the
formation of the adhesion layer reduces grain growth of the
group IVB metal, thereby improving the eventual performance of
the conductive material.

Representative claim 1 is reproduced as follows:

1. A method of producing a semiconductor device
having a contact hole in a layer on a substrate of
the device, comprising the steps of:

forming an insulating layer on a semiconductor
substrate;

forming a contact hole in the insulating layer
to expose a selected portion of the semiconductor

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substrate, the contact hole being defined by walls of the insulating layer;

forming an adhesion layer of a metal element selected from the group consisting of Ti, Zr, and Hf in the contact hole to be in contact with the exposed substrate, the adhesion layer being formed by reducing, with H₂, a gas of a halogenated product of the metal element in an ECR plasma CVD process, the gas of a halogenated product of the metal element and H₂ being used at a (gas of said halogenated product)/H₂ flow ratio equal to or greater than 0.4;

forming a barrier layer in contact with the adhesion layer, said adhesion layer and barrier layer being formed in successive steps in a chamber; and

filling the contact hole with an electrically conductive material.

The Examiner relies on the following prior art:

Shankar et al. (Shankar)	4,782,380	
Nov. 01, 1988		
Yokoyama et al. (Yokoyama)	4,897,709	Jan. 30,
1990		
Dixit et al. (Dixit)	4,960,732	Oct. 02,
1990		
Sandhu et al. (Sandhu)	5,173,327	Dec. 22,
1992		
Akahori et al. (Akahori '404)	5,296,404	Mar.
22, 1994		
Akahori (Akahori '066)	5,508,066	Apr. 16,
1996		

(filed Sep. 14, 1994)

M. A. Nicolet (Nicolet) "Diffusion Barriers in Thin Films,"

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Thin Solid Films, vol. 52, pgs. 415-443 (1978).

Claims 1-6 and 8-16 stand finally rejected under 35
U.S.C.

§ 103(a). As evidence of obviousness, the Examiner offers Akahori '066, Sandhu, Yokoyama, Akahori '404, and Nicolet with respect to claims 1-4, 6, 8-13, and 16, and adds Shankar and Dixit to the basic combination with respect to claims 5, 14, and 15. Claims 1-6 also stand finally rejected under the second paragraph of 35 U.S.C. § 112 as being indefinite for failure to particularly point out and distinctly claim the invention.

Rather than reiterate the arguments of Appellant and the Examiner, reference is made to the Briefs¹ and Answer for the

¹ The Appeal Brief was filed June 4, 1997. In response to the Examiner's Answer dated September 16, 1997, a Reply Brief was filed November 17, 1997 which was acknowledged and entered by the Examiner without further comment as indicated in the communication dated January 28, 1998.

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respective details.

OPINION

We have carefully considered the subject matter on appeal, the rejections advanced by the Examiner, the arguments in support of the rejections and the evidence of obviousness relied upon by the Examiner as support for the prior art rejection. We have, likewise, reviewed and taken into consideration, in reaching our decision, Appellant's arguments set forth in the Briefs along with the Examiner's rationale in support of the rejections and arguments in rebuttal set forth in the Examiner's Answer.

Appellant indicates (Brief, page 6) that claims 1-6 stand or fall together as a group while claims 8-15 stand or fall together as a separate group. Consistent with this indication, separate arguments for patentability have been provided only for the limitations recited in independent claims 1 and 8, which we will select as the representative claims for each group. We will consider the claims separately only to the extent that

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separate arguments are of record in this appeal.² Note In re King, 801 F.2d 1324, 1325, 231 USPQ 136, 137 (Fed. Cir. 1986); In re Sernaker, 702 F.2d 989, 991, 217 USPQ 1, 3 (Fed. Cir. 1983).

It is our view, after consideration of the record before us, that claims 1-6 particularly point out the invention in a manner which complies with 35 U.S.C. § 112, second paragraph. It is further our view that the evidence relied upon and the level of skill in the particular art would have suggested to one of ordinary skill in the art the obviousness of the invention as set forth in claims 1-6 and 16. We reach the opposite conclusion with respect to claims 8-15. Accordingly, we affirm-in-part.

With respect to the Examiner's 35 U.S.C. § 112, second paragraph, rejection of appealed claims 1-6, we note that a claim must set out and circumscribe a particular area with a reasonable degree of precision and particularity when read in light of the disclosure as it would be by the artisan. In re

²From the record in this case, it is apparent that Appellant inadvertently omitted dependent claim 16 from its proper grouping with its base claim 1.

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Moore, 439 F.2d

1232, 1235, 169 USPQ 236, 238 (CCPA 1971). Acceptability of the claim language depends on whether one of ordinary skill in the art would understand what is claimed in light of the specification. Seattle Box Co. v. Industrial Crating & Packing, Inc., 731 F.2d 818, 826, 221 USPQ 568, 574 (Fed. Cir. 1984).

After reviewing the arguments of record, we are in agreement with Appellant (Brief, page 7) that no ambiguity or lack of clarity exists in the claim language. While the Examiner has objected to the language "equal to or greater than 0.4" in independent claims 1 and 5, no legal authority has been cited by the Examiner for the asserted principle that a recitation of an upper limit is required to establish the metes and bounds of the claims. While an open-ended recitation of a range of values is undisputedly broader than a bounded range recitation, it is well settled that the breadth of a claim is not to be equated with indefiniteness. In re Miller, 441 F.2d 689, 692, 169 USPQ 597, 600 (CCPA 1971).

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It is our view that the skilled artisan, having considered the specification in its entirety, would have no difficulty ascertaining the scope of the invention recited in claims 1-6. Therefore, the rejection of claims 1-6 under the second paragraph of 35 U.S.C. § 112 is not sustained.³

Turning to a consideration of the Examiner's 35 U.S.C. § 103(a) rejection of the appealed claims, we note that, as a general proposition in an appeal involving a rejection under 35 U.S.C. § 103, an Examiner is under a burden to make out a prima facie case of obviousness. If that burden is met, the burden of going forward then shifts to Appellant to overcome the prima facie case with argument and/or evidence. Obviousness is then determined on the basis of the evidence as a whole and the relative persuasiveness of the arguments. See In re Oetiker, 977 F.2d 1443, 1445, 24 USPQ2d 1443, 1444 (Fed. Cir. 1992); In re Hedges, 783 F.2d 1038, 1039, 228 USPQ 685,

³The Examiner, through apparent inadvertence, failed to include claim 16, which by dependence includes the language of claim 1 found objectionable by the Examiner, in this rejection.

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686 (Fed. Cir. 1986); In re Piasecki, 745 F.2d 1468, 1472, 223 USPQ 785, 788 (Fed. Cir. 1984); and In re Rinehart, 531 F.2d 1048, 1052, 189 USPQ 143, 147 (CCPA 1976).

With respect to the obviousness rejection of representative independent claim 1, after reviewing the Examiner's analysis (Answer, pages 4-7), it is our view that such analysis carefully points out the teachings of the applied prior art references, reasonably indicates the perceived differences between this prior art and the claimed invention, and provides reasons as to how and

why the prior art teachings would have been modified and/or combined to arrive at the claimed invention. In our opinion, the Examiner's analysis is sufficiently reasonable that we find that the Examiner has at least satisfied the burden of presenting a prima facie case of obviousness. The burden is, therefore, upon Appellant to come forward with evidence or arguments which persuasively rebut the Examiner's prima facie case of obviousness. Only those arguments actually made by

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Appellant have been considered in this decision. Arguments which Appellant could have made but chose not to make in the Briefs have not been considered [see 37 CFR § 1.192(a)].

In response, Appellant asserts that the Examiner has failed to establish a prima facie case of obviousness since the proposed combination of references "does not teach or suggest the claimed invention including the recited flow ratio to produce the adhesion layer as claimed." (Brief, page 9). Initially, Appellant contends that Sandhu, relied on by the Examiner to teach the claimed ratio of 0.4 or greater of a halogenated gas product (e.g. $TiCl_4$) to H_2 , is of little value to the skilled artisan since there is no recognition of the problem of grain growth of Ti in a contact hole addressed by Appellant.

After reviewing the prior art references in light of Appellant's argument, we are in general agreement with the Examiner's position as stated in the Answer. Contrary to Appellant's contention, we find clear suggestion in the cited references for the Examiner's combination. It is clear from the disclosure of Akahori '066 (e.g. column 5, lines 1-3) that

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full step coverage of the plasma deposited material in a contact hole is contemplated. We are convinced that the skilled artisan, seeking guidance as to the proper halogenated gas to H₂ flow ratio to achieve maximum coverage would be led to the teachings of Sandhu which suggests the proper flow ratio range of 0.1 to 0.5 of metal source gas to reactive gas (e.g. TiCl₄ to H₂) to achieve the desired full coverage result. It is not necessary that the references be combined for the same reasons as Appellant. The fact that Appellant has recognized another advantage which would flow naturally from the suggestions of the prior art, i.e. prevention of contact hole grain growth of Ti, cannot be the basis for patentability when the differences would otherwise be obvious. Ex parte Obiaya, 227 USPQ 58, 60 (Bd. Pat. App. & Inter. 1985).

Appellant further contends that none of the prior art, particularly Sandhu, teaches or suggests the particular claimed halogenated product to H₂ flow ratio of 0.4 or greater. We do not find such argument to be persuasive. It

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is apparent to us that Sandhu's disclosed flow ratio range of 0.1 to 0.5 overlaps the claimed flow ratio range of "equal to or greater than 0.4." Further, in factual situations where claimed ranges overlap or lie inside ranges disclosed by the prior art, a prima facie case of obviousness has been held to exist. In re Wertheim, 541 F.2d 257, 267, 191 USPQ 90, 100 (CCPA 1976); In re Geisler, 116 F.3d 1465, 1469-71, 43 USPQ2d 1362, 1365-66 (Fed. Cir. 1997).

This prima facie case serves to shift the burden to Appellant to come forward with evidence which establishes the criticality of the claimed range, generally by a showing that the claimed range achieves unexpected results relative to the prior art range, or that the prior art, in any material way, teaches away from the claimed range. In re Malagari, 499 F.2d 1297, 1301, 182 USPQ 549, 553 (CCPA 1974); In re Woodruff, 919 F.2d 1575, 1577, 16 USPQ2d 1934, 1936 (Fed. Cir. 1990); Ex parte Lee, 31 USPQ2d 1105, 1107 (Bd. Of Pat. App. & Inter. 1993).

In attempting to address this burden, Appellant refers

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to the description in the specification which includes comparative examples at pages 7-10 which indicate the complete conformal nature of a Ti layer with the inner surface of a contact hole at a plasma deposition flow rate of TiCl_4 to H_2 at a ratio of 0.8. In contrast, at a TiCl_4 to H_2 flow rate ratio of 0.2, a granular non-conformal Ti layer resulted. We do not find such evidence to be persuasive. We note initially that the burden is on Appellant to show that any difference in test results are in fact unexpected and significant. Ex parte Gelles, 22 USPQ2d 1318, 1319 (Bd. Pat. App. & Inter. 1992). Further, the evidence presented must be commensurate in scope with the claims which the evidence is offered to support. Where the claimed limitations in question involve a prescribed range of values, it is important to consider whether the showing of alleged unexpected results occurs over the entire claimed range. In re Clement, 622 F.2d 1029, 1036, 206 USPQ 289, 296 (CCPA 1980). Our review of the comparative example evidence presented in Appellant's specification indicates a particular lack of a showing down to

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the 0.4 lower limit TiCl_4 to H_2 flow rate as claimed.

We further disagree with Appellant's contention that Sandhu's disclosure of flow rate values lower than the claimed 0.4 value amount to a teaching away from the claimed invention. Each reference must be read, not in isolation, but for what it fairly teaches in combination with the prior art as a whole. It is improper to downgrade a reference on the basis that it teaches away, unless it teaches away in the context of the combination of references. In re Keller, 642 F. 2d 413, 425, 208 USPQ 871, 881 (CCPA 1981); In re Merck & Co., Inc., 800 F. 2d 1091, 1096, 231 USPQ 375, 380 (Fed. Cir. 1986). In our view, Sandhu's teaching of a flow rate ratio 0.4 or greater as presently claimed is not devalued because of the suggested flow rate ratios below the claimed lower 0.4 limit.

As to Appellant's argument (Brief, page 13) that the Examiner has failed to consider evidence of non-obviousness in the specification, we agree with the Examiner that, contrary to Appellant's assertion, this evidence has in fact been

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considered. This consideration is not made in a vacuum however but, rather, evaluated along with evidence of obviousness present in the record. In our opinion, the evidence relied upon by Appellant

when weighed against the substantial evidence of obviousness is not sufficient to overcome the Examiner's prima facie case and, accordingly, the Examiner's 35 U.S.C. § 103(a) rejection of representative claim 1, and claims 2-6 and 16 which fall with claim 1, is sustained.

We next consider the Examiner's obviousness rejection of representative independent claim 8 and note that, while we found Appellant's arguments to be unpersuasive with respect to representative claim 1 discussed supra, we reach the opposite conclusion with respect to claim 8. Instead of a recited flow rate ratio of "equal to or greater than 0.4" as in claim 1, a value within the flow rate range taught in the prior art, claim 8 recites a flow rate ratio of "approximately 0.8", a value

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outside of any of the ranges of the prior art.⁴ Despite a lack of any explicit teaching of the claimed flow rate ratio in the prior art, the Examiner nevertheless suggests (Answer, pages 6 and 12) the obviousness to the skilled artisan of arriving at the claimed

flow rate ratio value through routine optimization. Our review of the record in this application, however, reveals a total lack of support for the Examiner's position. We are not inclined to dispense with proof by evidence when the proposition at issue is not supported by a teaching in a prior art reference, common knowledge or capable of unquestionable demonstration. Our reviewing court requires this evidence in order to establish a prima facie case. In re Knapp-Monarch Co., 296 F.2d 230, 232, 132 USPQ 6, 8 (CCPA 1961); In re Cofer, 354 F.2d 664, 668, 148 USPQ 268, 271-72 (CCPA 1966).

⁴The Examiner did not question the definiteness of the language "approximately 0.8" and no rejection based on the second paragraph of 35 U.S.C. § 112 is before us. In applying prior art to claim 8, the Examiner interpreted "approximately 0.8" as reciting a value higher than 0.5, the highest flow rate ratio suggested by the prior art, an interpretation which we do not find to be unreasonable.

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For the above reason, since all of the limitations of representative independent claim 8 are not taught or suggested by the prior art, the Examiner has not established a prima facie case of obviousness. Accordingly, the Examiner's 35 U.S.C. § 103 rejection of independent claim 8, as well as claims 9-15 dependent thereon, is not sustained.

In summary, we have not sustained the Examiner's 35 U.S.C. § 112, second paragraph, rejection of claims 1-6. With respect to the Examiner's 35 U.S.C. § 103 rejection of the appealed claims, we have sustained the rejection of claims 1-6 and 16, but

have not sustained the rejection of claims 8-15. Therefore, the Examiner's decision rejecting claims 1-6 and 8-16 is affirmed-in-part.

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

AFFIRMED-IN-PART

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