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. 22

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES

Ex parte PEIJUN DING,
TONY CHIANG, and
BARRY L. CHIN

Appeal No. 2001-2544
Application No. 08/995,108

ON BRIEF

Before WALTZ, DELMENDO, and MOORE, *Administrative Patent Judges*.

MOORE*, Administrative Patent Judge.*

DECISION ON APPEAL

This is an appeal under 35 U.S.C. § 134 from the final rejection of claims 8-27. Claims 1-7 have been canceled. Thus, only claims 8-27 are before us on this appeal.

REPRESENTATIVE CLAIMS

Claims 8, 13, 18, 21, 23, and 27 are representative of the claims on appeal, and read as follow:

8. A method of producing a combined barrier layer and wetting layer structure which is used in combination with a conductive layer, said method comprising the steps of:

a) depositing a first layer of TaN_x having a thickness ranging from greater than about 10 Å to about 1000 Å;

b) depositing a second layer of Ta having a thickness ranging from about 5 Å to about 500 Å; and

c) depositing a conductive layer over a surface of said second layer of Ta, wherein the substrate temperature during said conductive layer deposition and in subsequent processing steps is less than about 500°C.

13. The method of Claim 8, wherein said combined barrier layer and wetting layer structure is used in a contact via structure, and wherein the thickness of said TaN_x layer ranges from about 10 Å to about 300 Å and the thickness of said Ta layer ranges from about 5 Å to about 300 Å.

18. The method of Claim 8, wherein at least a portion of said Ta layer is deposited using ion-deposition sputtering.

21. A method of producing a copper interconnect structure comprising a combined TaN_x/Ta barrier layer and wetting layer, and an overlying copper layer, wherein the Cu <111> crystallographic content of said overlying copper layer is at least 70% of the Cu <111> crystallographic content which can be obtained by depositing said copper layer over a pure Ta barrier layer which is about 500 Å thick, said method comprising the steps of:

a) depositing a first layer of TaN_x having a thickness ranging from greater than about 50 Å to about 1,000 Å;

b) depositing a second layer of Ta having as thickness ranging from about 5 Å to about 500 Å over the surface of said first layer of TaN_x; and

c) depositing a third layer of copper over the surface of said second layer of Ta, wherein at least a portion of said third layer of copper is deposited using a physical vapor deposition technique, and wherein the substrate temperature at which said third layer of copper is deposited is less than about 500°C.

23. A method of producing a copper-comprising contact via structure comprising a combined TaN_x/Ta barrier layer and wetting layer, and an overlying copper layer, wherein the Cu <111>

crystallographic content of said overlying copper layer is at least 70% of the Cu {111} [sic, <111>] crystallographic content which can be obtained by depositing said copper layer over a pure Ta barrier layer which is about 300 Å thick, said method comprising the steps of:

a) depositing a first layer of TaN_x having a thickness ranging from greater than about 10 Å to about 300 Å;

b) depositing a second layer of Ta having as thickness ranging from about 5 Å to about 300 Å over the surface of said first layer of TaN_x; and

c) depositing a third layer of copper over the surface of said second layer of Ta, wherein at least a portion of said third layer of copper is deposited using a physical vapor deposition technique, and wherein the substrate temperature at which said third layer of copper is deposited is less than about 500°C.

27. A method of producing a copper-comprising contact structure comprising a combined TaN_x/Ta barrier layer and wetting layer, and an overlying copper layer, wherein the Cu <111> crystallographic content of said overlying copper layer is at least 70% of the Cu <111> crystallographic content which can be obtained by depositing said copper layer over a pure Ta barrier layer which is about 300 Å thick, said method comprising the steps of:

a) depositing a first layer of TaN_x having a thickness ranging from greater than about 10 Å to about 300 Å;

b) depositing a second layer of Ta having as thickness ranging from about 5 Å to about 300 Å over the surface of said first layer of TaN_x; and

c) depositing a third layer of copper over the surface of said second layer of Ta, wherein at least a portion of said third layer of copper is deposited using a physical vapor deposition technique, and wherein the substrate temperature at which said third layer of copper is deposited is less than about 500°C,

wherein at least a portion of said first layer, or said second layer, or said third layer, or a portion of a combination of said layers, is deposited using ion-deposition sputtering.

The References

In rejecting the claims under 35 U.S.C. § 103(a), the examiner relies upon the following references:

Hoshino	4,985,750	Jan. 15, 1991
Gelatos et al. (Gelatos)	5,391,517	Feb. 21, 1995
Landers et al. (Landers)	5,676,587	Oct. 14, 1997
Ngan	5,707,498	Jan. 13, 1998 (filed Jul. 12, 1996)

The Rejections

Claims 8-17 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Gelatos in view of Landers.

Claims 8-17 and 21-26 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Hoshino in view of Landers.

Claims 18-20 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Gelatos in view of Landers for claims 8-17, and further in view of Ngan.

Claims 18-20 and 27 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Hoshino in view of Landers for claims 8-17, and further in view of Ngan.

The Invention

The invention relates to a TaN_x/Ta barrier/wetting layer which increases the degree of crystal orientation in an overlying copper layer, thereby providing greater electromigration resistance of the copper (Specification, page 1, lines 5-7).

The Rejection of Claims 8-17 Under 35 U.S.C. § 103(a)

The examiner has found that Gelatos teaches a method of producing a barrier layer for the subsequent overlay of a conductive layer which includes the deposition (via sputtering) of a first layer of TiN_x followed by a second layer of Ti, both layers being 100-300 Å. A copper conductive layer is deposited while keeping the temperature at 190°C. (Examiner's Answer, page 3, lines 4-17).

The examiner further has found that Gelatos suggests the use of Ta for the nitride, and that Landers teaches the use of a Ta/TaN or Ti/TiN as barrier layers. The examiner thus concludes that it would have been obvious to employ Ta and its corresponding nitride in the barrier layer of Gelatos as they are equivalents. (Examiner's Answer, page 4, lines 1-14).

Our review of Gelatos reveals that it is quite explicit in teaching an interface layer between copper and the underlying semiconductor substrate preferably including a titanium sputtered onto the dielectric to a thickness of 100-300 angstroms, followed by a titanium nitride sputtering at a thickness of 300-500 angstroms, followed by a titanium sputtering at a thickness of about 100-300 angstroms. Copper is then deposited thereon. (See column 3, line 39-column 4, line 38). The copper is preferably deposited using a cold wall deposition system maintained at a

temperature of about 190°C (column 5, lines 11-13). It is also taught that tantalum can replace the titanium nitride. (Column 3, lines 56-57). The only perceptible difference between Gelatos and the instant claim is the inclusion of tantalum/tantalum nitride for titanium/titanium nitride.

The examiner has stated that titanium/titanium nitride and tantalum/tantalum nitride "stacks" are known equivalents. Our review causes us to agree with the examiner that, at the time the invention was made, titanium/titanium nitride and tantalum/ tantalum nitride were indeed well known as equivalent adhesive/ barrier layers.[1] Thus, we concur that exchanging Ta/TaN for Ti/TiN would have been obvious to one of ordinary skill in the art at the time the invention was made. As stated in In re Fout, 675 F.2d 297, 301, 213 USPQ 532, 536 (CCPA 1982) "Express suggestion to substitute one equivalent for another need not be present to render such substitution obvious."

The appellants argue that Gelatos teaches away from the present invention by preferring simple annealing at 500°C-600°C over the lower temperature of 400°C-500°C under forming gas (Appeal Brief, page 9, lines 7-15). This argument is unpersuasive for two reasons. First, a reference is available for all that it discloses and suggests, even nonpreferred

embodiments. See In re Lamberti, 545 F.2d 747, 750, 192 USPQ 278, 280 (CCPA 1976); and In re Mills, 470 F.2d 649, 651, 176 USPQ 196, 198 (CCPA 1972). Second, even the nonpreferred embodiment touches upon the claimed range of "about 500°C." When the difference between the claimed invention and the prior art is the range or value of a particular variable, then a prima facie rejection is properly established when the difference in the range or value is minor. Haynes Int'l. Inc. v. Jessop Steel Co., 8 F.3d 1573, 1577 n.3, 28 USPQ2d 1652, 1655 n.3 (Fed. Cir. 1993).

Also, a claimed invention is rendered prima facie obvious by the teachings of a prior art reference that discloses a range that touches the range recited in the claim. In re Malagari, 499 F.2d 1297, 1303, 182 USPQ 549, 553 (CCPA 1974). See also In re Woodruff, 919 F.2d 1575, 1578, 16 USPQ2d 1934, 1936 (Fed. Cir. 1990). We therefore remain unpersuaded by this first contention.

The appellants also urge that Landers' disclosure includes the tantalum nitride being deposited over the tantalum, and therefore the tantalum nitride is in contact with the overlying metal structure. The appellants assert that their tantalum layer must be in contact with the copper to obtain the invention benefits. Therefore, they conclude, Landers does not teach the present invention. (Appeal Brief, page 9, line 25 – page 10,

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1 In addition to Shacham-Diamond et al., see, e.g., US Patent 6,065,424, filed

line 7).

While we agree that the physical structure of Landers is not arranged as in the appellants' claim, it is, as the examiner correctly points out, the physical structure of Gelatos which is receiving the known substitution of equivalents. The Gelatos Ti/TiN layers as arranged would have been exchanged for Ta/TaN, which results in the claimed invention. We therefore are not persuaded by this contention.

The appellants have argued claims 13 and 14 separately, as requiring a layer thickness of TaN_x of between 10 angstroms to about 300 angstroms, and a Ta layer thickness of from about 5 angstroms to about 300 angstroms. The thrust of their argument is that the claimed dimensions are specifically useful for a contact via structure and not described in either Gelatos or Landers. (Appeal Brief, page 10, line 25 – page 12, line 6).

While this argument has a certain logic to it, it is not consistent with the claimed subject matter. As the examiner has pointed out, claim 13 recites that the claimed layers can be as thick as "about 300" angstroms. Gelato's titanium layer is 100-300 angstroms, while the titanium nitride layer is from 300-500 angstroms. As noted above, these ranges overlap and therefore would have been obvious. Further, although Gelatos exemplifies

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December 18, 1996, column 5, lines 28-30.

an interconnect, use in a contact via structure would have been obvious, given the teaching of general applicability, and to connections with via structures (column 6, lines 51 et seq.).

Finally, a thickness change to adapt a product to an end use does not render the claimed subject matter unobvious. It is not inventive to discover optimum or workable ranges by routine experimentation, and appellants have the burden of proving any criticality. In re Boesch, 617 F.2d 272, 276, 205 USPQ 215, 218-19 (CCPA 1980); In re Aller, 220 F.2d 454, 456, 105 USPQ 233, 235 (CCPA 1955). We are therefore not persuaded by this argument.

The Rejection of Claims 8-17 and 21-26 Under 35 U.S.C. §103(a)

The examiner has found that Hoshino teaches a sputter deposited first layer, a second layer of Ta deposited thereon and a physical vapor deposition of copper over the barrier layer. Landers is said to teach a Ta/TaN barrier combination is well known and desired, therefore, it would have been obvious to modify Hoshino to include the Ta/TaN layer of Landers. (Examiner’s Answer, page 5, lines 3-20).

The appellants argue that Hoshino’s layers are the reverse of their claimed order. (Appeal Brief, page 13, lines 3—20). We note that the embodiment disclosed at Hoshino, column 3, lines 20-column 4, line 14 results in a structure from top to bottom of:

Cu/Ta, TaN, W, WN, ZrN, TiC, WC or TiN/Ti or Al or Pt/SiO2/Si. Selecting the claimed compound of tantalum for the barrier layer results in:

Cu/Ta/Ti.[2]

Here the rejection fails. The examiner states that Landers discloses that Ta/TaN is a known combination for a barrier layer. We accept that general statement, but we question the motivation for replacing the disclosed barrier layer of Hoshino with that of Landers.

Why should one exchange the Ta/Ti barrier layer for Ta/TaN, other than for the reason it is taught by the instant specification? The stated motivation provided by the examiner, to prevent diffusion and electromigration, is already accomplished by the Hoshino layer. (Hoshino, abstract, lines 6-9).

These circumstances lead us to conclude that the examiner, in making his Section 103 rejection, has fallen victim to the insidious effect of hindsight syndrome wherein that which only the inventor has taught is used against its teacher. W. L. Gore & Assocs. v. Garlock, Inc., 721 F.2d 1540, 1553, 220 USPQ 303, 312-13 (Fed. Cir. 1983), cert. denied, 469 U.S. 851 (1984). We

2 Using the reasoning from the previous rejection, it is equally logical to select Cu/TiN/Ti and replace that with TaN/Ta as a known functional equivalent. This is, of course, the inverse of the claimed layer arrangement.

therefore reverse this rejection.

The Rejection of Claims 18-20 and 27 Under 35 U.S.C. §103(a)

Claims 18-20 and 27 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Hoshino in view of Landers for claims 8-17, and further in view of Ngan.

As we have reversed the underlying rejection of claims 8-17, we likewise reverse this rejection for the same reasons.

The Rejection of Claims 18-20 Under 35 U.S.C. §103(a)

Claims 18-20 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Gelatos in view of Landers for claims 8-17, and further in view of Ngan.

The examiner has found that Ngan teaches that in the manufacture of semiconductor devices, ion deposition sputtering is preferred over traditional sputtering in order to have uniform step coverage and filling of contact hole vias. Ngan utilized ion deposition sputtering to deposit an equivalent set of layers, titanium and titanium nitride; therefore, the examiner concludes, it would have been obvious to further modify Gelato's invention by using ion-deposition sputtering because Ngan teaches ion deposition sputtering improves deposition in semiconductor manufacturing. (Examiner's Answer, page 6, line 18 – page 7, line 6).

The appellants urge that ion deposition sputtering is a

defined term in the specification and it indicates a particular ionized content in material deposited on a substrate surface. (Appeal Brief, page 17, lines 14-20). We disagree.

Ion deposition sputtering is defined as sputter deposition using a high density inductively coupled RF plasma between the sputtering cathode and the substrate support electrode, whereby at least a portion of the sputtered emission is in the form of ions at the time it reaches the substrate surface. (Specification, page 8, lines 14-19). There is no particular content of ions, merely “a portion”. Ngan’s sputtering technique is evidently the same.

Thus, as it reasonably appears to be the same technique, we are unpersuaded by the contention that somehow the statement that “[t]ypically, 10% or more of the sputtered emission is in the form of ions at the time it reaches the substrate surface” defines over the Ngan process when combined with the Gelatos and Landers references.

The appellants additionally contend that even this combination makes it only “obvious to try” which is not the correct standard of patentability (Appeal Brief, page 18, lines 1-15). We disagree with their interpretation of Ngan. First, Gelatos is not limited to any particular type of sputtering and is generic to all types. Second, Ngan contains a clear teaching

that ionization sputtering is generally better, especially for high aspect ratio surfaces (Column 1, line 55). The use of ionized sputtering in conjunction with the deposition of the Ta/TaN layers would have been obvious to one of ordinary skill in the art at the time the invention was made, not merely obvious to try. Accordingly, we affirm this rejection.

Summary of Decision

The rejection of claims 8-17 under 35 U.S.C. § 103(a) as being unpatentable over Gelatos in view of Landers is sustained.

The rejection of claims 8-17 and 21-26 under 35 U.S.C. §103(a) as being unpatentable over Hoshino in view of Landers is reversed.

The rejection of claims 18-20 under 35 U.S.C. §103(a) as being unpatentable over Gelatos in view of Landers for claims 8-17, and further in view of Ngan, is sustained.

The rejection of claims 18-20 and 27 under 35 U.S.C. §103(a) as being unpatentable over Hoshino in view of Landers for claims 8-17, and further in view of Ngan, is reversed.

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

THOMAS A. WALTZ Administrative Patent Judge	)	
ROMULO H. DELMENDO Administrative Patent Judge	)	BOARD OF PATENT APPEALS AND INTERFERENCES
JAMES T. MOORE Administrative Patent Judge	)	

JM/ki

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