



IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

IN RE APPLICATION OF: Peijun Ding et al.

SERIAL NO.: 08/995,108

FILED: December 19, 1997

FOR: A TAILORED BARRIER LAYER WHICH PROVIDES IMPROVED COPPER INTERCONNECT ELECTROMIGRATION RESISTANCE

§ GROUP ART UNIT: 1753
§
§ EXAMINER: J. Mercado
§
§ Attorney Docket No.:
§ AM-1776
§
§
§

5 A/W.M.
2/15/00

Date: February 1, 2000

AMENDMENT "A"
UNDER 37 C.F.R. § 1.111

Hon. Assistant Commissioner of Patents
Washington, D.C. 20231

Sir:

This Amendment "A" is in response to the Office Action mailed September 2, 1999, having a shortened statutory period for response of December 2, 1999. A Petition for a two month extension of time to reply accompanies this Amendment "A", to extend the time to respond through February 2, 1000.

Claims 1 - 27 are pending in the application.

CERTIFICATE OF MAILING UNDER 37 CFR 1.10

I hereby certify that this paper and any documents said to accompany this paper are being deposited with the U.S. Postal Service on the date shown below with sufficient postage as U.S. EXPRESS MAIL NO. EL372083921US in an envelope addressed to the: Assistant Commissioner for Patents, Box Non-Fee Amendment, Washington DC 20231.

Shirley L. Church
Shirley L. Church, Reg. No. 31,858

Date: February 1, 2000

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Claims 1 - 27 are subject to restriction requirement.

Claims 21 - 27 are rejected under 35 USC § 112, first paragraph, as containing subject matter which was not described in the specification in such a way as to enable one skilled in the art to which it pertains, or with which it is most nearly connected, to make and/or use the invention.

Claims 22 and 24 - 26 are rejected under 35 USC § 112, first paragraph, as being dependent upon a rejected base claim.

Claims 21 - 27 are rejected under 35 USC § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

Claims 22 and 24 - 26 are rejected under 35 USC § 112, second paragraph, as being dependent upon a rejected base claim.

Claims 8 - 11, 14, 15, and 17 are rejected under 35 USC § 102(b) as being anticipated by U.S. Patent No. 5,281,485, to Colgan et al.

Claims 8 - 17 are rejected under 35 USC § 103(a) as being unpatentable over U.S. Patent No. 5,391,517, to Gelatos et al., in combination with U.S. Patent No. 5,676,587, to Landers et al.

Claims 8 - 17 and 21 - 26 are rejected under 35 USC § 103(a) as being unpatentable over U.S. Patent No. 4,985,750, to Hoshino, in view of Landers et al.

Claims 8 - 17 are rejected under 35 USC § 103(a) as being unpatentable over U.S. Patent No. 5,240,880, to Hindman et al., in view of either Landers et al. or Hoshino.

Claims 12, 13, and 16 are rejected under 35 USC § 103(a) as being unpatentable over Colgan et al., in view of either Landers et al., Gelatos et al., or Hoshino.

Claims 18 - 20 are rejected under 35 USC § 103(a) as being unpatentable over Gelatos et al., in combination with Landers et al., as applied to Claims 8 - 17, above, and further in view of U.S. Patent No. 5,707,498, to Ngan.

Claims 18 - 20 and 27 are rejected under 35 USC § 103(a) as being unpatentable over Hoshino, in view of Landers et al., as applied to Claims 8 - 17, above, and further in view of Ngan.

Claims 18 - 20 are rejected under 35 USC § 103(a) as being unpatentable over Colgan et al., in view of either Landers et al., Gelatos et al., or Hoshino, as applied to Claims 12, 13, and 16, above, and further in view of Ngan.

Please amend the application as follows:

IN THE SPECIFICATION:

Page 4, line 7, prior to "crystallographic", please delete "{111}" and insert -- <111>--;

line 8, prior to "content", please delete "{111}", and insert -- <111>; and,

line 12, prior to "crystal", please delete "{111}", and insert -- <111>--;

Page 5, line 1, after "aluminum", please delete "{111}", and insert -- <111>--;

line 14, prior to "crystal", please delete "{111}", and insert -- <111>--; and,

line 18, after "high", please delete "{111}", and insert -- <111>--.

Page 6, after line 17 and prior to line 18, please insert the following as a new paragraphs.

-- We have also developed a method of producing a copper interconnect structure comprising a copper layer deposited over a barrier layer structure of the kind described above, comprising a Ta layer overlying a TaN_x layer, where the Cu <111> crystallographic content is at least 70 % of the Cu <111> crystallographic content which can be obtained by depositing the copper layer over a pure Ta barrier layer which is about 500 Å thick. The method comprises 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 a thickness ranging from about 5 Å to about 500 Å over the surface of the first layer of TaN_x; and

c) depositing a third layer of copper over the surface of the second layer of Ta, wherein at least a portion of the third layer of copper is deposited using a physical vapor deposition technique, and

wherein the substrate temperature at which the third layer of copper is deposited is less than about 500°C.

Further, we have developed a method of producing a copper-comprising contact via structure comprising a copper layer deposited over a barrier layer structure of the kind described above, comprising a Ta layer overlying a TaN_x layer, wherein the Cu <111> crystallographic content 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. The method comprises the steps of:

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

In the method of producing a copper-comprising contact structure described above, a least a portion of the first layer of TaN_x, or the second layer of Ta, or the third layer of Cu, or at least a portion of more than one of these three layers may be deposited using ion-deposition sputtering, where at least a portion of the sputtered emission is in the form of ions at the time the emission reaches the substrate surface, and where, typically 10 % or more of the sputtered emission is in the form of ions at the time the emission reaches the substrate surface. --

Page 6, line 21, after "copper", please delete "{111}" and insert -- <111> -- .

Page 7, line 4, after "high", please delete "{111}" and insert -- <111> -- .

Page 12, line 16, after "tantalum", please delete "{002}" and insert -- <002> -- ; and,

- line 17, after "high", please delete "{111}", and insert -- <111> --.
- Page 13, line 4, after "copper", please delete "{111}", and insert -- <111> --; and,
line 8, after "copper", please delete "{111}", and insert -- <111> --;
line 10, after "copper", please delete "{111}", and insert -- <111> --;
line 14, after "copper", please delete "{111}", and insert -- <111> --;
line 15, after "copper", please delete "{111}", and insert -- <111> --;
line 20, after "copper", please delete "{111}", and insert -- <111> --;
line 23, prior to "crystallographic", please delete "{111}", and insert -- <111> --.
- Page 14, line 15, prior to "intensity", please delete "{111}", and insert -- <111> --;
line 16, prior to "CPS", please delete "{111}", and insert -- <111> --;
line 19, prior to "orientation", please delete "{111}", and insert -- <111> --; and,
line 21, prior to "FWHM", please delete "{111}", and insert -- <111> --.
- Page 15, line 8, prior to "crystallographic", please delete "{111}", and insert -- <111> --;
line 13, after "Cu", please delete "{111}", and insert -- <111> --;
line 15, after "Cu", please delete "{111}", and insert -- <111> --;
line 20, after "Cu", please delete "{111}", and insert -- <111> --;
line 23, after "Cu", please delete "{111}", and insert -- <111> --; and
line 24, after "Cu", please delete "{111}", and insert -- <111> --.
- Page 16, line 3, after "Cu", please delete "{111}", and insert -- <111> --;
line 8, after "Cu", please delete "{111}", and insert -- <111> --;
line 11, after "Cu", please delete "{111}", and insert -- <111> --;
line 14, after "Cu", please delete "{111}", and insert -- <111> --;
line 15, after "copper", please delete "{111}", and insert -- <111> --; and
line 19, after "high", please delete "{111}", and insert -- <111> --.
- Page 23 (abstract), line 22, after "high", please delete "{111}", and insert -- <111> --.

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