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BEFORE THE PATENT TRIAL AND APPEAL BOARD

Ex parte BRETT H. ENGEL, DOMINGO A. FERRER,
ARUN VIJAYAKUMAR, and KEITH KWONG HON WONG[1]

Appeal 2018-002415
Application 15/164,063
Technology Center 2800

Before BRADLEY R. GARRIS, ROMULO H. DELMENDO, and
LILAN REN, *Administrative Patent Judges*.

GARRIS, *Administrative Patent Judge*.

DECISION ON APPEAL

Appellant appeals under 35 U.S.C. § 134 from the Examiner's decision rejecting claims 1–8. We have jurisdiction under 35 U.S.C. § 6.

We AFFIRM.

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[1] Appellant is the Applicant, International Business Machines Corporation, which is identified as the real party in interest (App. Br. 1).

Appellant claims a method of forming a titanium nitride diffusion barrier comprising exposing a deposition surface to a pulse of a titanium-containing precursor gas and providing first, second, third, and fourth pulses of a nitrogen-rich plasma to form first through fourth titanium nitride layers with first through fourth nitrogen concentrations, wherein the first through fourth titanium nitride layers form a multi-layer titanium nitride diffusion barrier exhibiting gradually decreasing levels of fluorine diffusivity, the fluorine diffusivity of the titanium nitride layers being inversely proportional to a duration of the pulses of nitrogen-rich plasma and to a nitrogen concentration of the titanium nitride layers (sole independent claim 1).

A copy of representative claim 1, taken from the Claims Appendix of the Appeal Brief, appears below.

> 1. A method of forming a titanium nitride diffusion barrier, the method comprising:
>
> exposing a deposition surface to a pulse of a titanium-containing precursor gas to initiate a nucleation of the titanium nitride diffusion barrier in the deposition surface, wherein the deposition surface comprises sidewalls and a bottom of a contact opening;
>
> exposing the deposition surface to a first pulse of a nitrogen-rich plasma to form a first titanium nitride layer with a first nitrogen concentration in the deposition surf ace;
>
> exposing the first titanium nitride layer to a second pulse of the nitrogen-rich plasma to form a second titanium nitride layer with a second nitrogen concentration directly above and in contact with the first titanium nitride layer;
>
> exposing the second titanium nitride layer to a third pulse of the nitrogen-rich plasma to form a third titanium nitride layer with a third nitrogen concentration directly above and in contact with the second titanium nitride layer; and

> exposing the third titanium nitride layer to a fourth pulse of the nitrogen-rich plasma to form a fourth titanium nitride layer with a fourth nitrogen concentration directly above and in contact with the third titanium nitride layer,
>
> wherein the first, second, third, and fourth titanium nitride layers form a multi-layer titanium nitride diffusion barrier exhibiting gradually decreasing levels of fluorine diffusivity, the fluorine diffusivity of the first, second, third, and fourth titanium nitride layers is inversely proportional to a duration of the first, second, third, and fourth pulses of nitrogen-rich plasma and to a nitrogen concentration of the first, second, third, and fourth titanium nitride layers.

The Examiner rejects claims 1–8[2] on the ground of nonstatutory double patenting as being unpatentable over claims 8, 11–16, 19, and 20 of U.S. Patent No. 9,406,554 B2 (Final Action 3).

As the Examiner correctly observes (Ans. 2), Appellants do not challenge the propriety of this rejection (*see generally* App. Br.). Therefore, we summarily sustain the double patenting rejection of claims 1–8 without further comment.

The Examiner also rejects claims 1–8 under 35 U.S.C. § 103 as being unpatentable over Ritchie (US 2010/0151676 A1; June 17, 2010) in view of Konecni (US 6,455,419 B1; Sept. 24, 2002) (Final Action 5–9).

[2] Claims 9–13 are withdrawn from consideration as being directed to a non-elected invention (Final Action 4).

In rejecting claim 1, the Examiner finds that Ritchie discloses a method of forming a titanium nitride diffusion barrier comprising steps involving a pulse of a titanium-containing precursor gas and first through fourth pulses of a nitrogen-rich plasma to form first through fourth titanium nitride layers (*id.* at 5–6). The Examiner also finds that these titanium nitride layers "form a multi-layer titanium nitride diffusion barrier proportional to a duration of the . . . pulses of nitrogen-rich plasma and to a nitrogen concentration of the . . . titanium nitride layers" (*id.* at 6). In addition, the Examiner finds that, while "Ritchie does not teach titanium nitride layer prevents fluorine from diffusing," Konecni provides such a teaching and concludes that it would have been obvious "to include the above teaching in order to show the characteristic of the titanium nitride layer[s of Ritchie] as taught by Konecni" (*id.*).

Appellant argues that the applied references contain no teaching or suggestion of the claim limitation "a multi-layer titanium nitride diffusion barrier exhibiting gradually decreasing levels of fluorine diffusivity, the fluorine diffusivity of the . . . titanium nitride layers is inversely proportional to a duration of the . . . pulses of nitrogen-rich plasma and to a nitrogen concentration of the . . . titanium nitride layers" (claim 1) (App. Br. 4; *see also id.* at 5–8). Specifically, Appellant argues that "Ritchie teaches repeating a single set of deposition and [nitrogen-rich] plasma treatment steps in a loop fashion" (*id.* at 5–6) but that "[a]t no point does Ritchie teach or suggest varying the conditions of those multiple plasma treatments" (*id.* at 6). Appellant similarly argues that "Ritchie merely recites 'the nitrogen concentration of the titanium nitride barrier layers may be increased by

adding a supplemental nitrogen precursor'" (*id.* at 7–8 (citing Ritchie ¶ 25)) but that "Ritchie fails to teach varying the added supplemental nitrogen precursor to vary the nitrogen concentration of the individual titanium nitride barrier layers" (*id.* at 8).

In response, the Examiner states that "[Ritchie's] method [of densifying titanium nitride layers with nitrogen] is increasing the level of nitrogen concentration in titanium nitride material and higher duration time because of further time need[ed] to process and it is taking place from the layers 314a and 314b and beyond" (Ans. 4 (emphasis omitted)).

Appellant replies to this statement by correctly pointing out that "the Examiner fails to cite any portion of Ritchie as supporting the allegation that a 'higher duration time [of the densification is required] because of further time need[ed] to process [the titanium nitride layers, i.e., based on the nitrogen concentration increase]'" (Reply Br. 7).

The Examiner does not provide the appeal record with any evidence supporting the proposition that Ritchie alone or in combination with Konecni teaches or would have suggested varying pulse duration and nitrogen concentration thereby resulting in the above quoted features of claim 1. For this reason, we do not sustain the § 103 rejection of claims 1–8 as unpatentable over Ritchie in view of Konecni.

In summary, we have sustained the double patenting rejection but have not sustained the § 103 rejection.

DECISION

The decision of the Examiner to reject claims 1–8 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). *See* 37 C.F.R. § 1.136(a)(1)(iv).

AFFIRMED