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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Ex parte SCOTT EDWARD FULLER, BRIAN ROBERTS ROUTH JR., and MICHAEL MORIARTY

Appeal 2017-010462
Application 13/899,278
Technology Center 1700

Before RAE LYNN P. GUEST, JULIA HEANEY, and JEFFREY R. SNAY, *Administrative Patent Judges*.

SNAY, *Administrative Patent Judge*.

DECISION ON APPEAL[1]

Appellants[2] appeal under 35 U.S.C. § 134(a) from the Examiner's decision rejecting claims 1–5, 7–16, 18, 21, and 22. We have jurisdiction pursuant to 35 U.S.C. § 6(b).

We reverse.

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[1] We cite to the substitute Specification ("Spec.") filed August 16, 2013; Final Office Action ("Final Act.") dated September 27, 2016; Appellants' Appeal Brief ("App. Br.") dated March 9, 2017; Examiner's Answer ("Ans.") dated June 6, 2017; and Appellants' Reply Brief ("Reply Br.") dated August 6, 2017.

[2] Appellants identify FEI Company as the real party in interest. App. Br. 3.

BACKGROUND

The invention relates preparation of a sample lamella for transmission electron microscopy (TEM) inspection. Spec. ¶ 2. According to Appellants' Specification, critical pattern dimensions in a semiconductor manufacturing process can be monitored by TEM inspection of a thin (e.g., less than 100 nm thick) lamella that is milled from an area of interest on a semiconductor substrate. *Id.* at ¶¶ 5–7. Appellants' process for forming a lamella includes operating an ion beam to mill in a line raster pattern, such that each subsequent cut removes less material than the previous cut. *Id.* at ¶ 66. The final line raster is operated to make the opposing lamella faces orthogonal to the wafer surface. *Id.* Consequently, the milled lamella includes a shelf or ledge section which slopes away from a thinned observation window such that, in cross-section, the window and ledge portions take the form of an inverted Y. *Id.* at ¶¶ 26, 56, 66, Figs. 6A, 6B. Claim 1—the sole independent claim on appeal—reads as follows:

> 1. A method of forming a lamella having an observation face for transmission electron microscope observation of a feature of interest in the observation face, comprising:
>
> directing a charged particle beam toward a work piece in the vacuum chamber of a charged particle beam system to induce deposition from a precursor gas of a protective layer above the feature of interest, the ratio of the sputtering rate of the work piece and the sputtering rate of the protective layer being within a ratio of 1.5 to 1 and a ratio of 1:1, the work piece comprising silicon;
>
> directing a focused ion beam toward the sample to mill one or more fiducials near the feature of interest;
>
> directing the focused ion beam to mill cavities on both sides of the region of interest to form a lamella;
>
> from each side of the lamella, directing the focused ion beam to mill progressively closer to the observation face from

> the cavity, *successively milling to remove less material from the lamella as the beam approaches the region of interest to provide a bottom surface of the lamella that slopes away from the observation face*, the ions in the focused ion beam having a first landing energy;
>
> after milling progressively closer to the observation face from the cavity, milling to remove material separating the cavities to leave tabs supporting the cavity;
>
> after milling to remove material separating the cavities, directing an ion beam toward the observation face, the ion beam having a second landing energy, lower than the first landing energy.

App. Br. 17 (Claims Appendix) (emphasis added to highlight the key recitation in dispute).

REJECTIONS

I. Claims 1–5, 7–16, 21, and 22 stand rejected under 35 U.S.C. § 103(a) as unpatentable over Blackwood,[3] Wanzenboeck,[4] and Tsai.[5]

II. Claims 1–5, 7–16, 21, and 22 stand rejected under 35 U.S.C. § 103(a) as unpatentable over Blackwood, Hahnel,[6] Wanzenboeck, and Tsai.

III. Claim 18 stands rejected under 35 U.S.C. § 103(a) as unpatentable over Blackwood, Wanzenboeck, Tsai, and Wells.[7]

IV. Claim 18 stands rejected under 35 U.S.C. § 103(a) as unpatentable over Blackwood, Hahnel, Wanzenboeck, Tsai, and Wells.

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[3] US 2010/0300873 A1, published December 2, 2010 ("Blackwood").
[4] US 2010/0276601 A1, published November 4, 2010 (Wanzenboeck").
[5] US 6,080,991, issued June 27, 2000 ("Tsai").
[6] Hahnel, A. et al., Nano-beam electron diffraction evaluation of strain behavior in nano-scale patterned strained silicon-on-insulator, *Phys. Status Solidi*, C 8, No. 4, 1319–24 (2011).
[7] US 2009/0218488 A1, published September 3, 2009 ("Wells").

DISCUSSION

A dispositive issue in this case is whether the Examiner reversibly erred in finding that Tsai teaches forming a lamella having a bottom surface that slopes away from an observation face. *Compare* Final Act. ¶ 14 ("Tsai teaches a method of forming a lamella . . . to provide a bottom surface of the lamella that slopes away from the observation face."), *with* App. Br. 12 ("Applicants respectfully disagree that Tsai teaches a method of forming a lamella . . . to provide a bottom surface that slopes away from the observation face."), and Reply Br. 7 ("The cited prior art does not teach forming a bottom surface of the lamella that slopes away from the observation face.").

Blackwood discloses using a focused ion beam to mill a lamella having a thinned observation window that is suitable for TEM inspection. Blackwood ¶ 67. By decreasing scan speed of the beam as the beam is stepped closer to the window face, the milling depth increases, resulting in a milled trench that slopes toward the observation window. *Id.* ¶ 78, Fig. 19C.

The Examiner acknowledges that Blackwood teaches forming a bottom lamella surface that slopes toward, rather than away from, the observation face. Ans. 16 ("Blackwood teaches sloping in the opposite direction as claimed."). However, the Examiner finds that Tsai teaches "forming a lamella by successive etching steps wherein less material is removed from the lamella as the beam approaches the region of interest to provide a bottom surface of the lamella that slopes away from the observation face." Final Act ¶ 14. The Examiner relies on Tsai's Figures 3 and 4 and the corresponding discussion at column 1, line 62, through column

2, line 30. Final Act. ¶¶ 14, 35. There, Tsai refers to a conventional milling process in which "[a] slanted surface **410** of the TEM observable wall is automatically formed due to FIB milling."[8] Tsai 2:17–19. Such a slanted TEM observable wall is depicted in Tsai's Figure 4, labeled as prior art, which we reproduce below:

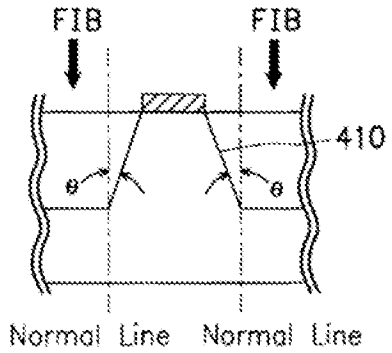

FIG. 4 (PRIOR ART)

Figure 4 is a schematic drawing of a cross-sectional view of a TEM test slice. Tsai 2:15–16.

In light of the foregoing disclosure in Tsai, the Examiner finds that one of ordinary skill in the art would have had a reason to substitute Tsai's milling operation as a known "functionally equivalent" milling method. Final Act. ¶¶ 14, 35. *See also*, Ans. 16 ("One of ordinary skill in the art would certainly be able to select from one of these known methods to form a suitable lamella with predictable expectations of successfully forming lamella suitable for TEM viewing.").

One problem with the Examiner's reasoning is that, even if one were to adopt Tsai's so-called conventional milling technique in Blackwood's window milling process, the result would have been a sloping observation

[8] FIB refers to a focused ion beam. Tsai 1:33–34.

face—surface **410** in Tsai's Figure 4—rather than a surface that "slopes away from the observation face" as is called for in claim 1. *See* Tsai 2:24–25 ("[T]he TEM observable wall is gradually wider from the top to the bottom."). The Examiner fails to identify evidence in Tsai, or elsewhere in the record, of successively milling to remove less material from the lamella as the beam approaches the region of interest, so as to form both an observation face *and* a bottom surface that slopes away from the observation face. The Examiner, therefore, fails to set forth a factual basis which is sufficient to support a determination that it would have been obvious to modify Blackwood's milling process in a manner that would have produced a lamella having a bottom surface that slopes away from an observation face.

Because each of Rejections I–IV is premised on the same erroneous finding that Tsai teaches forming a lamella having bottom surface that slopes away from an observation face, these Rejections are not sustained.

DECISION

The Examiner's decision rejecting claims 1–5, 7–16, 18, 21, and 22 is reversed.

REVERSED