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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Ex parte TAKAOMI SUZUKI and MASAKI SAKAMOTO

Appeal 2019-000041
Application 15/254,770
Technology Center 2800

Before ROMULO H. DELMENDO, MICHAEL P. COLAIANNI, and
CHRISTOPHER C. KENNEDY, *Administrative Patent Judges*.

COLAIANNI, *Administrative Patent Judge*.

DECISION ON APPEAL

Pursuant to 35 U.S.C. § 134(a), Appellant¹ appeals from the Examiner's decision to reject claims 1 to 5. We have jurisdiction under 35 U.S.C. § 6(b).

We AFFIRM.

Appellant's invention is directed to method of manufacturing a semiconductor device which is suitable for manufacturing a "revese [sic]

¹ We use the word "Appellant" to refer to "applicant" as defined in 37 C.F.R. § 1.42. Appellant identifies the real party in interest as Sumitomo Heavy Industries, Ltd. Appeal Br. 3.

conducting IGBT (RC-IGBT)” in which an insulating gate bipolar transistor (IGBT) and a diode are formed on one substrate (Spec. ¶ 1; Claim 1).

Claim 1 is representative of the subject matter on appeal:

1. A method of manufacturing a semiconductor device comprising:

(a) a process of forming a first injection region by ion-injecting a first conduction type of first dopant into a surface layer portion of an IGBT section of a semiconductor substrate including a surface in which the IGBT section and a diode section are defined;

(b) a process of forming a second injection region by ion-injecting a second dopant of a second conduction type which is the opposite to the first conduction type into a shallower region of the IGBT section of the semiconductor substrate than the first injection region;

(c) a process of forming a third injection region by ion-injecting the first conduction type of third dopant into a surface layer portion of the diode section of the semiconductor substrate at a concentration higher than the concentration of the second dopant so that the injected region becomes amorphized;

(d) a process of scanning the IGBT section and the diode section of the semiconductor substrate with a first pulse laser beam under conditions in which the third injection region is partially melted and the first dopant of the first injection region is activated after the processes (a), (b), and (c); and

(e) a process of melting and crystallizing a surface layer portion which is shallower than the second injection region in the entire region of the IGBT section and the diode section of the semiconductor substrate by scanning the IGBT section and the diode section of the semiconductor substrate with a second pulse laser beam having a pulse width shorter than the pulse width of the first pulse laser beam after the process (d).

Appellant appeals the following rejection:

Claims 1 to 5 are rejected under 35 U.S.C. § 103 as

unpatentable over Toshiba² (JP2013-197122, published Sept. 30, 2013) in view of Kimura³ (JP2008-41868, published Feb. 21, 2008), Nagase (US 2007/0194346 A1, published Aug. 23, 2007) and Nakagawa (US 2002/0100934 A1, published Aug. 1, 2002).

Appellant argues the claims as a group (Appeal Br. 8–22). Therefore, we select claim 1 as representative of the group. 37 C.F.R. § 41.37(c)(iv).

FINDINGS OF FACT & ANALYSIS

The Examiner’s findings and conclusions regarding the rejection of claim 1 over Toshiba in view of Kimura, Nagase, and Nakagawa are located on pages 5 to 10 of the Non-Final Action.

Appellant argues that Toshiba fails to disclose or suggest a second pulse laser beam having a pulse width shorter than the pulse width of the first laser beam (Appeal Br. 11). Appellant contends that Kimura teaches that using a pulse laser to anneal a doped semiconductor wherein the second pulse width of the laser is longer than the pulse width of the first pulse (Appeal Br. 12). Appellant argues that Nagase and Nakagawa fail to teach using a second laser pulse have a pulse width that is shorter than the first laser pulse width (Appeal Br. 14). Appellant contends that the Examiner’s findings and conclusions regarding the combined teachings of Toshiba, Kimura, Nagase, and Nakagawa lack articulated reasoning with some

² Our review is based upon Toshiba’s English-language equivalent, US 2013/0240947 A1 published September 19, 2013.

³ We refer to the machine translation of Kimura obtained from the Japan Patent Office website: <https://www.j-platpat.inpit.go.jp/p0200>.

rational underpinning to support the legal conclusion of obviousness (Appeal Br. 15). Appellant contends that the Examiner provides no objective evidence to support that it would have been obvious to use a second laser pulse with a shorter pulse width than the first laser pulse width (Appeal Br. 15; Reply Br. 5, 7). Appellant argues that the Examiner's analysis is based upon conclusory statements and impermissible hindsight (Appeal Br. 15, 21). Appellant argues that the Examiner has not shown a relationship between the variable (i.e., pulse width) and the affected property (i.e., dopant activation depth), which precludes a determination that the particular variable is a result-effective variable (Appeal Br. 16). Appellant contends that Kimura provides no comparison between an activation depth of the first pulse P1 and an activation depth of the second pulse P2 (Reply Br. 11).

The Examiner finds that Toshiba fails to teach, *inter alia*, using a pulse laser to anneal a semiconductor, but the Examiner finds that Nagase teaches using a pulse laser to anneal and Kimura teaches using a series of pulses having different pulse widths (Non-Final Act. 5–10). The Examiner relies on Nagase and Nakagawa to teach that particular dopant concentrations would have yielded an amorphous structure when laser annealed, which Appellant does not dispute (Non-Final Act. 6–8; Appeal Br. *generally*). The Examiner finds that Kimura teaches that it was known at the time of the invention to use pulsed laser annealing to target specifically different depths of implanted dopants in a semiconductor while limiting the melting, diffusion, and recrystallization of the region being targeted (Non-Final Act. 9). The Examiner finds that Kimura teaches a pulsed laser anneal that will specifically target the region at the greater depth, and a second

pulsed laser anneal having a shorter width for targeting the surface regions (Non-Final Act. 9).

Although Appellant argues that no objective evidence has been provided to support the Examiner's finding that the Kimura teaches a relationship between the depth of impurity activation and the pulse width, the Examiner finds that Kimura teaches that a pulsed laser targets different depths of an implanted region (Non-Final Act. 9). Indeed, Kimura discloses that the problem to be solved relates to "an impurity activating method which increases the activation depth of a plurality of laser pulses each irradiated in suitable conditions onto a substrate including a semiconductor layer with an impurity added to its surface layer" (Kimura, Abstract, ¶ 6). Kimura discloses that the first laser pulse (i.e., the shorter pulse width in the particular embodiment) melts the surface of the region and the second laser pulse (i.e., the longer pulse width in the embodiment) is applied to maintain the melted portion at a high temperature to increase the impurity activation depth (Kimura ¶¶ 8, 10). Kimura appears to teach a separate embodiment where a first pulse width may be longer than the second pulse width (Kimura ¶ 9, 82). Kimura further teaches that a laser pulse having a pulse width is suitable for impurity activation by controlling the temperature of the wavelength conversion element included in the first pulse laser light source (Kimura ¶ 11, 76). Kimura teaches that peak energy is directly related to pulse width such that the peak energy increases when the pulse width increases and peak energy decreases when the pulse width decreases⁴

⁴ Pulse energy = pulse width x peak power. Rearranging that equation yields: Peak power = Pulse energy/Pulse width. In other words, Pulse energy and Pulse width are directly related.

(Kimura ¶ 47). Kimura teaches that the first and second pulse width may be controlled with controller 100 to achieve a target pulse width (Kimura ¶¶ 39, 52, 56). Kimura further teaches that the pulse width of the first pulse (i.e., 200 ns or less) and second pulse (i.e., 100 ns or more) overlap (¶¶ 78, 79, 83).

The Examiner's finding that Kimura teaches a relationship between laser annealing pulse width and the depth of impurity activation in the implanted region is supported by Kimura's disclosures. Objective evidence has been provided by the Examiner. Therefore, we agree with the Examiner that one of ordinary skill in the art would have determined the suitable pulse width and pulse width order (i.e., short pulse width then longer pulse width or vice versa) to affect the desired depth of activation for the dopant profile based on the evidence of record. The Examiner's findings are not based upon impermissible hindsight, but rather the teachings and suggestions provided by the references.

Appellant further argues that unexpected results support a conclusion of nonobviousness (Appeal Br. 20–21). Appellant appears to contend that paragraph 40 of the Specification provides a comparison of the invention with prior art which shows that by using the claimed invention pulse width order, “*the surface layer portion of the second surface 14 can be annealed without damaging the device structure of the IGBT formed on the first surface 13.*” (Appeal Br. 20–21) (emphasis omitted). Although Appellant cites to paragraph 40 of the Specification, Appellant has not carried the burden of explaining how the citation shows unexpected results as it is Appellant's burden to do. *Ex parte Ishizaka*, 24 USPQ2d 1621, 1624 (BPAI 1992) (citing *In re Payne*, 606 F.2d 303 (CCPA 1979)). Nevertheless,

paragraph 40 of the Specification discloses that the shorter pulse width of the second pulse width suppresses an increase in temperature of the first surface 13 while the second surface 14 is heated to a melting temperature. The use of a shorter pulse width to suppress an increase in temperature seems to comport with Kimura's disclosure that the shorter pulse width melts the surface of the impurity implanted region while the longer pulse width laser provides deeper impurity activation by maintaining the temperature to a deeper region of the semiconductor structure (Kimura ¶¶ 8, 10). Appellant appears to achieve the same result with a shorter pulse width laser pulse as Kimura does with a shorter pulse width laser pulse (i.e., melting at only the semiconductor surface). In other words, Appellant's allegation of evidence of non-obviousness does not appear to be non-obvious or unexpected.

On this record, Appellant has not shown reversible error in the Examiner's § 103 rejection.

CONCLUSION

In summary:

Claims Rejected	35 U.S.C. §	Reference(s)/Basis	Affirmed	Reversed
1-5	103	Toshiba, Kimura, Nagase, Nakagawa	1-5	

No time period for taking any subsequent action in connection with this appeal may be extended under 37 C.F.R. § 1.136(a). *See* 37 C.F.R. § 1.136(a)(1)(iv).

AFFIRMED