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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Ex parte JOHN MICHAEL GUERRA

Appeal 2020-000098
Application 14/680,999
Technology Center 1700

Before TERRY J. OWENS, CATHERINE Q. TIMM, and
JEFFREY B. ROBERTSON, *Administrative Patent Judges*.

ROBERTSON, *Administrative Patent Judge*.

DECISION ON APPEAL¹

¹ This Decision includes citations to the following documents: Specification filed April 4, 2015 and as amended on February 22, 2017 (“Spec.”); Final Office Action mailed June 5, 2018 (“Final Act.”); Appeal Brief filed November 5, 2018 (“Appeal Br.”); Examiner’s Answer mailed February 1, 2019 (“Ans.”); and Reply Brief filed April 30, 2019 (“Reply Br.”).

STATEMENT OF THE CASE

Pursuant to 35 U.S.C. § 134(a), Appellant² appeals from the Examiner's decision to reject claims 1–8, 10–14, and 17–26.³ Appeal Br. 15. We have jurisdiction under 35 U.S.C. § 6(b).

We affirm in part.

CLAIMED SUBJECT MATTER

Appellant states the invention relates to a bandgap-shifted semiconductor surface, and a method for making the same. Spec. ¶ 5. Claims 1 and 7, reproduced below, are illustrative of the claimed subject matter (Appeal Br., Claims Appendix 31–33):

1. A photoelectrolytic cell for production of first and second gases from a liquid, the cell comprising:
 - a container capable of holding the liquid;
 - a photoelectrode disposed within the container and capable of generating the first gas upon exposure to radiation, said photoelectrode having been produced by a process comprising:
 - (a) etching titanium metal to form a titanium nano-structured surface on said titanium metal; and
 - (b) oxidizing at least part of the nano-structured titanium to titania by at least one of (i) anodizing the titanium in an anodizing solution, and (ii) heating the titanium in an oxygen-containing atmosphere, wherein the titania film produced in step (b) is stressed by the nanostructures produced in step (a), the stress causing the titania film to have a bandgap therein to support spontaneous photoelectrolysis of water in visible light;

² We use the word “Appellant” to refer to “applicant” as defined in 37 C.F.R. § 1.42. Appellant identifies Nanoptek Corporation as the real party in interest. Appeal Br. 3.

³ Claims 9, 15, and 16 have been cancelled. *See* Appeal Br. 5.

a counterelectrode disposed within the container electrically connected to the photoelectrode and capable of generating a second gas when the photoelectrode is exposed to radiation; and

a membrane arranged between the photoelectrode and the counterelectrode to separate the first and second gases.

7. A photoelectrolytic cell for production of at least one gas from a liquid, the cell comprising:

a container capable of holding the liquid;

a photoanode disposed within the container;

a cathode disposed within the container and electrically connected to the photoanode, such that when the photoanode is exposed to radiation, at least one gas will be generated by the photoanode and the cathode; and

a second anode disposed within the container, the second anode not being photolytically active but being electrically connected to the cathode,

said photoanode comprising a semiconductor film on a substrate, the semiconductor film having a bandgap not supporting spontaneous photoelectrolysis of water in visible light wavelengths present in sunlight, the substrate having surface undulations with a spatial period smaller than the wavelength of visible light that cause stress in the semiconductor film and thereby shift the bandgap therein to support spontaneous photoelectrolysis of water in visible light.

Independent claims 10 and 23 also stand rejected, and are directed to an apparatus and a photo-reactor core assembly means, respectively. *Id.* at 33–36.

REFERENCES

The prior art relied upon by the Examiner is:

Name	Reference	Date
Kilby et al. hereinafter "Kilby"	US 4,021,323	May 3, 1977
Powell	US 4,278,829	July 14, 1981
Murphy	US 4,722,776	Feb. 02, 1988
Pritchard	US 5,592,028	Jan. 07, 1997
Scannell et al. hereinafter "Scannell"	US 5,660,698	Aug.26, 1997
Converse	US 6,015,950	Jan. 18, 2000
Guerra	US 2003/0228727 A1	Dec. 11, 2003
Shifman	US 2005/0046977 A1	Mar. 3, 2005
A. G. Imenes et al. hereinafter "Imenes"	"Spectral beam splitting technology for increased conversion efficiency in solar concentrating systems: a review" Solar Energy Materials & Solar Cells 84 (2004) 19–69.	June 1, 2004
X. Quan et al. hereinafter "Quan"	"Preparation of Titania Nanotubes and Their Environmental Applications as Electrode" Environ. Sci. Technol. 2005, 39, 3770–3775.	2005

R. Markle	“Etching Titanium with HF and Nitric Acid Solutions Part 1” Chemcut Corporation	2015
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REJECTIONS

1. The Examiner rejected claims 1, 5, 6, and 21 under 35 U.S.C. § 103(a) (pre-AIA) as unpatentable over Guerra, Quan, with evidence from Markle. Final Act. 3–5.
2. The Examiner rejected claim 2 under 35 U.S.C. § 103(a) (pre-AIA) as unpatentable over Guerra, Quan, and Scannell. Final Act. 5–6.
3. The Examiner rejected claims 3 and 4 under 35 U.S.C. § 103(a) (pre-AIA) as unpatentable over Guerra, Quan, and Murphy. Final Act. 6–7.
4. The Examiner rejected claim 22 under 35 U.S.C. § 103(a) (pre-AIA) as unpatentable over Guerra, Quan, and Kilby. Final Act. 7.
5. The Examiner rejected claim 25 under 35 U.S.C. § 103(a) (pre-AIA) as unpatentable over Guerra, Quan, and Pritchard. Final Act. 7–8.
6. The Examiner rejected claim 7 under 35 U.S.C. § 103(a) (pre-AIA) as unpatentable over Guerra and Murphy. Final Act. 8–9.
7. The Examiner rejected claim 8 under 35 U.S.C. § 103(a) (pre-AIA) as unpatentable over Guerra, Murphy, and Scannell. Final Act. 9.
8. The Examiner rejected claims 10, 17, and 20 under 35 U.S.C. § 103(a) (pre-AIA) as unpatentable over Imenes, Guerra, Converse, and Quan, with evidence from Markle. Final Act. 9–12.

9. The Examiner rejected claims 11 and 12 under 35 U.S.C. § 103(a) (pre-AIA) as unpatentable over Imenes, Guerra, Converse, Quan, and Shifman. Final Act. 12.
10. The Examiner rejected claim 13 under 35 U.S.C. § 103(a) (pre-AIA) as unpatentable over Imenes, Guerra, Converse, Quan, and Powell. Final Act. 12–13.
11. The Examiner rejected claim 14 under 35 U.S.C. § 103(a) (pre-AIA) as unpatentable over Imenes, Guerra, Converse, Quan, and Kilby. Final Act. 13–14.
12. The Examiner rejected claims 18 and 19 under 35 U.S.C. § 103(a) (pre-AIA) as unpatentable over Imenes, Guerra, Converse, Quan, and Murphy. Final Act. 14–15.
13. The Examiner rejected claim 26 under 35 U.S.C. § 103(a) (pre-AIA) as unpatentable over Imenes, Guerra, Converse, Quan, and Pritchard. Final Act. 15.
14. The Examiner rejected claim 23 under 35 U.S.C. § 103(a) (pre-AIA) as unpatentable over Guerra, Quan, and Scannell, with evidence from Markle. Final Act. 15–17.
15. The Examiner rejected claim 24 under 35 U.S.C. § 103(a) (pre-AIA) as unpatentable over Guerra, Quan, Scannell, Imenes, Converse, and Shifman. Final Act. 17–19.

OPINION

Rejection 1

We limit our discussion to claim 1, which is sufficient to dispose of this rejection.

The Examiner's Rejection

In rejecting claim 1 as unpatentable over Guerra and Quan, the Examiner found Guerra discloses a photoelectrolytic cell having the structure recited in claim 1, but Guerra discloses a photoelectrode made by vacuum deposition of titania, rather than forming a titania photoelectrode by the etching and oxidizing steps on titanium recited in claim 1. Final Act. 4. The Examiner found Quan discloses a method of preparing titania nanotube electrodes where a titanium sheet is immersed in a chemical etchant, and then anodized to produce a titania film with a structure of nanotubes. *Id.* The Examiner determined it would have been obvious to have substituted the titania film of Quan for the titania film of Guerra, because Quan discloses the titania film disclosed therein increases the photoconversion ability of titania. *Id.* at 5.

Appellant's contentions

Appellant does not dispute that Guerra discloses the basic apparatus recited in claim 1. Appeal Br. 18. Rather, Appellant contends, *inter alia*, that Quan does not disclose titania electrodes that have excellent photoelectrolytic properties for splitting water in visible light. *Id.* at 19–20. In particular, Appellant contends that the bandgap for the titania electrodes disclosed in Quan is larger than is required for efficient photoelectrolysis of water using sunlight. *Id.* at 20–22. Thus, Appellant contends that one of ordinary skill in the art would not have considered modifying Guerra to include the Quan electrode. *Id.* at 21.

Issue

Did the Examiner err in determining it would have been obvious to have substituted the titania nanotube film of Quan for the vacuum-deposited titania film in Guerra to produce a photoelectrolytic cell that “support[s] spontaneous photoelectrolysis of water in visible light” as recited in claim 1?

Discussion

We are persuaded by Appellant’s arguments. Guerra discloses a titania photocatalyst with a band gap that is shifted and broadened to be active for photoelectrolysis at wavelengths more prevalent in sunlight and artificial light. Guerra ¶ 17.

With respect to the shifting the band gap, Guerra discloses that the energy band gap of conventional titania electrodes is 3.0 eV, and requires artificial light such as a xenon lamp. Guerra ¶ 8. However, Quan discloses that the band gap of the titania nanotubes is 3.30 eV. Quan 3772, 1st column. Thus, Quan discloses a shift in the band gap of titania toward shorter wavelengths, i.e., away from wavelengths more prevalent in sunlight and deeper into UV wavelengths, which is the opposite of the band gap shift disclosed in Guerra. Indeed, Quan discloses evaluation of its titania nanotubes using UV irradiation via a high-pressure mercury lamp. *Id.* at 3771, 1st column.

In addition, although the Examiner points to Figure 5 of Quan for the position that the band gap of the titania nanotube is broadened because of the absorption (~0.1 Abs) shown in wavelengths from 400–500 nm (Ans. 21–22; Quan, p. 3772, Fig. 5, curve b), we agree with Appellant (Reply Br. 6) that Quan discloses band gap absorption range edge is 350 nm, such that one

of ordinary skill in the art would not have assigned any particular significance to the absorption in Figure 5 relied upon by the Examiner. Moreover, the Examiner's position that one of ordinary skill in the art would have been able to adjust the band gap that is capable of spontaneous photoelectrolysis of water in visible light in view of Guerra (Ans. 22, citing Guerra, ¶ 109) appears to be contrary to Quan's disclosure of shifting the bandgap toward shorter wavelengths. *See* Quan p. 3773, 1st column.

Although Quan discloses a titania electrode with a nanotube structure that is the "kind of electrode may find its important roles . . . in splitting of water to produce hydrogen and oxygen and selective organic synthesis" (Quan, p. 3770, 2nd column), and "photoconversion ability of titania by modification was greatly improved" (*id.* at 3774, 2nd column), in view of the above discussion, we do not view these disclosures to be sufficient to support the Examiner's rationale that it would have been obvious to have used Quan's titania nanotube film in Guerra's photoelectrolytic cell to have a band gap that "support[s] spontaneous photoelectrolysis of water in visible light" as recited in claim 1.

Accordingly, we reverse the Examiner's rejection of claim 1, and claims 5, 6, and 21 dependent therefrom.

Rejections 2–5 and 8–15

The Examiner's rejections of the claims including independent claims 10 and 23 suffer from the same deficiencies as discussed above with respect to claim 1 and Rejection 1, where each of those rejections rely on Guerra and Quan, and the added prior art references fail to remedy the deficiencies identified above. *See* Final Act. 5–19. In this regard, we observe that claim

23 expressly recites “the stress causing the titania film to have a lower bandgap than unstressed titania” such that Quan’s disclosure of an higher bandgap as discussed above is sufficient to demonstrate reversible error on the part of the Examiner.

Accordingly, we reverse the Examiner’s rejections for similar reasons as discussed above with respect to claim 1.

Rejection 6

The Examiner’s Rejection

In rejecting claim 7 over Guerra and Murphy, the Examiner found Guerra discloses a photoelectrolytic cell as recited in claim 7 including undulations in the titania surface with a spatial period smaller than the wavelength of visible light, which enhanced the ability of titania to conduct photolysis. Final Act. 8. The Examiner found, however, that Guerra fails to disclose a second anode disposed within the container, where the second anode is not photolytically active, but is electrically connected to the cathode. *Id.* The Examiner found Murphy discloses photoelectrolytic production of hydrogen was known, as was utilizing an external photovoltaic cell to energize an anode and a cathode located within a container. *Id.* The Examiner determined it would have been obvious to have added a second anode to the system of Guerra into a single container to permit application of additional electricity from an external source to produce more hydrogen and achieve higher rates of hydrogen production through the combination of the photoelectrolytic anode of Guerra and a non-photocatalytic anode. *Id.* at 8–9.

Appellant's contentions

Appellant contends Murphy does not support the idea of using a second non-photolytically active anode in the container as required in claim 7. Appeal Br. 25. Appellant argues Murphy discloses using an external electrical source increases costs, reduces efficiency, and increases space requirements, such that Murphy discloses elimination of an external electrical energy source. *Id.* at 26. Appellant argues Murphy discloses a device that keeps the light-activated semiconductor surface out of aqueous solution in order to overcome these problems, which teaches away from the modification of the Guerra apparatus as set forth in the Examiner's rejection. *Id.* at 27. Appellant argues Murphy discloses a compound electrode, where one side is a light-driven semiconductor device and the other side comprises an electrocatalyst, and where the two sides are connected via an ohmic layer. *Id.* Appellant contends Murphy does not disclose a non-photolytic electrode immersed in electrolyte or the use of external electrical power in his apparatus, such that even if combined, it would be impossible to electrically connect an external electrical power source between the photoelectrode of Murphy and the Guerra cathode as required by claim 7. *Id.* at 28.

Discussion

We are not persuaded by Appellant's arguments. As the Examiner points out, Murphy discloses multiple ways to conduct splitting of water in order to generate hydrogen gas. Ans. 25, citing Murphy, col. 1, ll. 25–32. The Examiner's rejection relies on combining a photoelectrolysis system as disclosed in Guerra with an electrolysis system of the prior art, where there is an external source of electric potential in a single container to provide a

system that is capable of functioning independently with light or with externally supplied electricity, or both simultaneously. *Id.* In this way, the Examiner found the combined apparatus would have the advantage of being able to operate during the day by solar energy and the available electricity source during the night or during periods of clouds. *Id.* Thus, the Examiner does not rely on the particular semiconductor electrodes or devices disclosed in Murphy.

In this regard, Appellant acknowledges that Murphy discloses an electrolyzer where the cathode and anode are in the container (Reply Br. 9), which is consistent with the Examiner's rationale. In addition, Appellant's argument that Murphy does not teach the addition of a photoelectrode within the container (Reply Br. 9–10) does not consider the Examiner's rejection as a whole, which relies on Guerra for the photoactive anode. Appellant's further argument that Guerra does not disclose a photoactive anode that comprises titania on a titanium substrate (Reply Br. 10) is also not persuasive, as it is not commensurate in scope with claim 7, which does not recite this feature.

Accordingly, we affirm the Examiner's rejection of claim 7.

Rejection 7

Appellant does not set forth separate arguments with respect to claim 8, which depends from claim 7, but rather relies on the dependency of claim 8 for its patentability. Appeal Br. 29.

Accordingly, we affirm the Examiner's rejection of claim 8 for similar reasons as discussed above with respect to claim 7.

DECISION SUMMARY

In summary:

Claims Rejected	35 U.S.C. §	Reference(s)/Basis	Affirmed	Reversed
1, 5, 6, 21	103(a)	Guerra, Quan, Markle		1, 5, 6, 21
2	103(a)	Guerra, Quan, Scannell		2
3, 4	103(a)	Guerra, Quan, Murphy		3, 4
22	103(a)	Guerra, Quan, Kilby		22
25	103(a)	Guerra, Quan, Pritchard		25
7	103(a)	Guerra, Murphy	7	
8	103(a)	Guerra, Murphy, Scannell	8	
10, 17, 20	103(a)	Imenes, Guerra, Converse, Quan, Markle		10, 17, 20
11, 12	103(a)	Imenes, Guerra, Converse, Quan, Shifman		11, 12
13	103(a)	Imenes, Guerra, Converse, Quan, Powell		13
14	103(a)	Imenes, Guerra, Converse, Quan, Kilby		14
18, 19	103(a)	Imenes, Guerra, Converse, Quan, Murphy		18, 19
26	103(a)	Imenes, Guerra, Converse, Quan, Pritchard		26
23	103(a)	Guerra, Quan, Scannell, Markle		23

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24	103(a)	Guerra, Quan, Scannell, Imenes, Converse, Shifman		24
Overall Outcome			7, 8	1-6, 10-14, 17-26

TIME PERIOD FOR RESPONSE

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 IN PART