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BEFORE THE PATENT TRIAL AND APPEAL BOARD

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*Ex parte* DAVID D. SMITH and TAESEOK KIM

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Appeal 2015-005090  
Application 12/940,821  
Technology Center 1700

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Before ADRIENE LEPIANE HANLON, MICHAEL P. COLAIANNI, and  
JEFFREY R. SNAY, *Administrative Patent Judges*.

COLAIANNI, *Administrative Patent Judge*.

DECISION ON APPEAL

Appellants appeal under 35 U.S.C. § 134 the final rejection of claims 1–10. We have jurisdiction over the appeal pursuant to 35 U.S.C. § 6(b).

We AFFIRM.

Appellants' invention is directed to solar cell fabrication processes and structures (Spec. ¶ 2). The claimed process allegedly lowers fabrication costs associated with forming solar cell diffusion regions (i.e. N-type and P-type regions) (Spec. ¶¶ 3, 4).

Claims 1, 8, and 9 are illustrative:

1. A method of fabricating a solar cell structure, the method comprising:  
forming a thin dielectric layer on a solar cell substrate;  
forming first silicon nano-particle diffusion regions of the solar cell structure by printing P-type doped silicon nano-particles over the thin dielectric layer;

forming second silicon nano-particle diffusion regions of the solar cell structure by printing N-type doped silicon nano-particles over the thin dielectric layer; and

*forming a continuous nano-particle film at least at an interface with the thin dielectric layer by heating the N-type and P-type doped silicon nano-particles at a sintering temperature less than a melting point of the N-type and P-type doped silicon nano-particles for an amount of time sufficient to form the continuous nano-particle film.*

(emphasis added)

8. The method of claim 1 further comprising:

forming a wetting agent on the thin dielectric prior to printing the N-type and P-type doped silicon nano-particles.

9. The method of claim 8 wherein the wetting agent comprises amorphous silicon.

Appellants appeal the following rejections:

1. Claims 1, 2, 4–6, and 10 are rejected under 35 U.S.C. § 103(a) as unpatentable over Swanson (US 2008/0121279 A1, published May

- 29, 2008) in view of Yasutomi et al. (US 5,271,871, issued Dec. 21, 1993) (“Yasutomi”).
2. Claim 3 is rejected under 35 U.S.C. § 103(a) as unpatentable over Swanson in view of Yasutomi and Shah et al. (US 7,615,393 B1, issued Nov. 10, 2009) (“Shah”).
  3. Claim 7 is rejected under 35 U.S.C. § 103(a) as unpatentable over Swanson in view of Yasutomi and Anthony et al. (US 3,936,319, issued Feb. 3, 1976) (“Anthony”).
  4. Claims 8 and 9 are rejected under 35 U.S.C. § 103(a) as unpatentable over Swanson in view of Yasutomi and Fu et al. (US 2008/0236665 A1, published Oct. 2, 2008) (“Fu”).

Appellants argue the subject matter of claims 1, 8, and 9 only (App. Br. 2–9). Claims 2–7 and 10 will stand or fall with our analysis of the rejection of the sole independent claim 1.

#### FINDINGS OF FACT & ANALYSIS

##### REJECTIONS (1), (2), AND (3): Claim 1

The Examiner finds that Swanson teaches the subject matter of claim 1, except for forming a continuous nano-particle film at least at an interface with the thin dielectric layer by heating the N-type and P-type doped silicon nano-particles at a sintering temperature less than a melting point of the N-type and P-type doped silicon nano-particles for an amount of time sufficient to form the continuous nano-particle film (Final Act. 3–4). The Examiner finds that Yasutomi teaches heating or sintering a mixture of particles to a temperature of less than the melting point of the particles to link the particles

together and to reduce voids and prevent a reduction of strength (Final Act. 4). The Examiner concludes that it would have been obvious to modify the method of Swanson by applying the sintering steps of Yasutomi to the N-type doped and P-type doped silicon nano-particles in order to link the silicon nano-particles together, reduce voids and prevent a reduction in strength as taught by Yasutomi. *Id.* The Examiner finds that the combination of Yasutomi's sintering step with Swanson's method is nothing more than the use of a known technique for its intended function in a known environment to accomplish an entirely expected result (Final Act. 5).

Appellants argue that Yasutomi does not teach heating silicon nano-particles as used by Swanson's method (App. Br. 3). Appellants contend that Yasutomi teaches not that sintering in general is beneficial, but rather that sintering a particular mold composition may be beneficial. *Id.* Appellants argue that Yasutomi teaches that it is important to use a binder in the composition to reduce voids and increase packing density. *Id.* Appellants contend that Yasutomi teaches heating metallic powder at a temperature below the melting point of the metallic powder and then further heating the metallic powder at high temperatures, which Appellants allege is above the melting point of the metallic powder (App. Br. 4). Appellants argue that Yasutomi does not consider the melting point of the silicon portion of the powder mixture when setting the heating temperature of the metallic powder. *Id.* Appellants argue that Yasutomi limits the amount of silicon in the powder mixture and even claims the metallic powder as being "*free of silicon.*" *Id.*

Contrary to Appellants' arguments, Yasutomi teaches that the particle mixture includes metallic particles and may include silicon particles sized to

be less than 100  $\mu\text{m}$  in order to control the resistivity of the layer (Yasutomi col. 3, ll. 12–38, 42–44). Yasutomi’s claim 1 does not recite that the particle mixture is free of silicon as argued by Appellants. Rather, claim 1 recites that the metallic powder is “free of Si” but the claim further recites that the inorganic compound of the particle mixture includes silicide or oxide silicide (Claims 1 and 3). Yasutomi’s claims comport with its disclosure that includes having a mixture of metallic particles and silicide particles. Indeed, Yasutomi’s Examples 10 and 11 in Table 2 in column 9 teaches that the ratio of metallic powder to silicon powder may be such that the silicon portion is the major component of the blend. We note that silicon has a melting point of  $1,420^{\circ}\text{C}$  and titanium has a melting point of  $1,800^{\circ}\text{C}$ <sup>1</sup>. Therefore, Yasutomi’s teaching to sinter the Ti:Si particle blend at a temperature below the melting point followed by raising the temperature to a value within the range of  $600$  to  $1350^{\circ}\text{C}$  would constitute heating the silicon particles to a temperature below its melting point. In other words, Yasutomi teaches sintering a particle blend with 90% silicon at a temperature below the silicon portion’s melting point (Example 11, Table 2, column 9).

Although Yasutomi teaches that by adding binder to the particle mixture the packing density of the particles and strength of the product can be increased (Yasutomi, col. 7, ll. 28–35), we note that Swanson also uses a surfactant on the silicon particles to aid in their deposition (Swanson ¶ 15). Also, the claim is open-ended and does not exclude the use of binder along with the silicon particles. Yasutomi further teaches that the particle blend can be made into a thin substrate by using a doctor blade method (col. 6, ll. 39, 47–48). Yasutomi further discloses that the sintering method expands

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<sup>1</sup> Perry’s Chemical Engineers’ Handbook, 6<sup>th</sup> Ed. pp. 3-20, 3-23.

the scope of use of the ceramics to include electronic parts such as, but not limited to, electrode materials, current collectors, commutators, etc. (col. 8, ll. 1–9). Yasutomi thus teaches how to provide a thin layer that may be made of silicon particles with improved strength and durability.

Appellants further argue that Swanson, directed to solar cells, and Yasutomi, directed to ceramic parts, are directed to different fields of endeavor (App. Br. 5). Appellants contend that Swanson is directed to electrical arts and Yasutomi is directed to mechanical arts. *Id.* Appellants contend that Yasutomi uses non-silicon containing metallic particles and Swanson uses silicon nano-particles. *Id.*

Appellants' argument only addresses whether Swanson and Yasutomi are in the same field of endeavor; the first prong of the analogous art test set forth in *In re Clay*, 966 F.2d 656, 659 (Fed. Cir. 1992). However, the court in *Clay* also stated that the art may be analogous if it is reasonably pertinent to Appellants' problem. *Clay*, 966 F.2d at 659.

The Examiner finds that Yasutomi is reasonably pertinent to Appellants' problem of processing particles so that the particles link together to form a continuous material (Ans. 8). Appellants do not meaningfully respond to this finding by the Examiner (Reply Br. 4). Rather, Appellants focus on the methods of molding in Yasutomi differing from the method of forming the silicon nano-particle layer in Swanson. *Id.* Appellants have not shown that Yasutomi's doctor blade method would have been detrimental to Swanson's device. Appellants' citation to Yasutomi on page 4 of the Reply Brief is taken out of context. Yasutomi teaches that doctor blade method may be used to form thin substrates. However, the sentence preceding that sentence is directed to molding using a mechanical press, a different method

from the doctor blade method (Yasutomi col. 6, ll. 35–48). No evidence has been provided by Appellants to show that Yasutomi’s doctor blade method of forming thin film would destroy Swanson’s solar cell. Nevertheless, Appellants’ response fails to address why Yasutomi’s method of sintering particles is not pertinent to Appellants’ problem, which is found by the Examiner to be processing particles to link them together.

Appellants’ argument that Yasutomi uses non-silicon containing particles is not accurate. Rather, Yasutomi teaches using non-silicon containing metallic particles as part of the particle blend that is used to form the molded article. The other portion of Yasutomi’s blend of particles may include silicon containing particles to aid in controlling the resistivity of the layer (col. 3, ll. 20–24). Swanson teaches depositing silicon nano-particles on a substrate to form N-type doped and P-type doped regions (Swanson ¶ 15). The Examiner relies on Yasutomi to teach that is known to sinter 1  $\mu\text{m}$  or less sized particles of silicon at a temperature below the particulate silicon’s melting point (Final Act. 4; Ans. 5).

Appellants contend that there is no support for the conclusion that Yasutomi’s process would yield a predictable result when applied to silicon nano-particle films in the manufacture of solar cells (App. Br. 6). Appellants argue that Yasutomi’s high temperature sintering may melt or change the electrical characteristics of silicon nano-particles and other films of the solar cell. *Id.*

Appellants’ argument provides no evidence to substantiate the mere attorney argument that forming Swanson’s silicon nano-particle layer using Yasutomi’s process would necessarily affect the electrical characteristics of the nano-particles or the other films of the solar cell. Rather, the Examiner

finds that Yasutomi's sintering temperature range (i.e., 600 to 1350°C) includes the same heat treatment temperature used by Appellants (i.e., 900°C) (Ans. 10). Accordingly, it appears that Yasutomi includes values within Appellants' claimed range. Moreover, Appellants' argument fails to appreciate that a person of ordinary skill is also a person of ordinary creativity not an automaton. *KSR Int'l Co. v. Teleflex Inc.*, 550 US 398, 421 (2007). A person of ordinary skill would appreciate that the process would be modified so as to avoid damage to sensitive layers of the solar cell layers. Appellants have not shown that making such a modification would have been beyond the ordinary skill in the art.

For the above reasons, the preponderance of the evidence favors the Examiner's conclusion that it would have been obvious to use Yasutomi's sintering method to sinter the N-type and P-type regions formed of silicon nano-particles on Swanson's substrate. We affirm the Examiner's § 103(a) rejections (1), (2) and (3) listed *supra*.

#### REJECTION (4): Claims 8 and 9

Claim 8 depends from claim 1 and recites "forming a wetting agent on the thin dielectric prior to printing the N-type and P-type doped silicon nano-particles."

Claim 9 depends from claim 8 and recites "wherein the wetting agent comprises amorphous silicon."

The Examiner rejects claims 8 and 9 over the combined teachings of Swanson in view of Yasutomi and Fu. The Examiner's findings regarding Swanson and Yasutomi are as indicated with regard to claim 1. The Examiner finds that Swanson and Yasutomi do not teach forming a wetting

agent on the thin dielectric prior to printing the N-type and P-type doped silicon nano-particles (claim 8), wherein the wetting agent comprises amorphous silicon (claim 9) (Final Act. 7).

The Examiner finds that Fu's ¶ 34 teaches pre-coating a substrate with molten silicon to alter the surface wettability and adhesion of the substrate (Final Act. 7). The Examiner finds that Fu's ¶ 40 and as shown in Figure 6 teaches using amorphous silicon as a wetting agent layer (Ans. 11). The Examiner concludes that it would have been obvious to modify the method of Swanson by forming a wetting agent of amorphous silicon as taught by Fu on the thin dielectric prior to printing the N-type or P-type doped silicon nano-particles in order to alter the surface wettability and adhesion as taught by Fu (Final Act. 7–8).

With regard to claim 8, Appellants argue that Fu's wetting agent is applied to glass substrate for altering the wettability and adhesion of molten silicon not printed silicon nano-particles (App. Br. 7). Appellants contend that there is no disclosure regarding why altering the surface wettability and adhesion would be beneficial to the modified Swanson (App. Br. 7). Appellants contend that the Examiner has not explained the extent of the proposed alteration to Swanson in light of Fu's teaching to stop the further wetting of silicon at a position on the substrate (App. Br. 7–8).

Appellants' arguments are not persuasive. Swanson teaches that surfactant (i.e., a wetting agent) may be applied to either the silicon nano-particles or the substrate (¶ 15). Therefore, Swanson, alone, recognizes that a wetting agent within the meaning of claim 8 may be used prior to silicon nano-particle deposition.

Regarding claim 9 Appellants argue that Fu's molten silicon is not a wetting agent and when the layer of silicon cools it is not amorphous silicon (App. Br. 8–9). The Examiner, however, finds that Fu's layer 44 constitutes an amorphous silicon wetting layer (Ans. 11). Appellants respond that Fu's layer 44 is between the silicon dioxide layer 43 and the silicon thin film base 45 (Reply Br. 6). Appellants contend that thin film base 45 is not a printed N-type and P-type doped silicon nano-particle layer and Fu fails to teach that the wetting agent will improve the adhesion of printed N-type and P-type doped silicon nano-particles to a thin dielectric. *Id.* Appellants contend that the Examiner has not provided articulated reasoning why one of ordinary skill in the art would form a wetting agent on the thin dielectric as modified by Swanson. *Id.*

Appellants' arguments in the Reply Brief fail to recognize that claim 9 as it ultimately depends on claim 1 is open-ended and does not preclude various additional layers between the dielectric layer and the N-type and P-type doped silicon nano-particles. Claim 1 recites "forming [first and second] silicon nano-particle diffusion regions [*over*] the solar cell structure" and "forming [] silicon nano-particle diffusion regions . . . *over* the thin dielectric layer" (emphasis added). Claim 8 recites "forming a wetting agent *on* the thin dielectric prior to printing" (emphasis added). Claims 1 and 8 does not require that the wetting agent be formed directly on the dielectric with no intervening layers. The claim does not recite that the wetting agent layer improves adhesion between the dielectric layer and the silicon nano-particle regions. Appellants' arguments are not commensurate in scope with the claimed subject matter.

Moreover, Swanson teaches to use a surfactant (i.e., wetting agent) on the surface along with the nano-particles (Swanson ¶ 15). Fu teaches that amorphous silicon is a known wetting agent (Fu ¶ 40). Therefore, it would have been obvious to use Fu's amorphous silicon wetting agent as the wetting agent in Swanson because such a combination is nothing more than the predictable use of prior art elements for their intended function (i.e., wetting agents). To that end, we note Appellants do not direct us to any evidence or present any technical reasoning showing that the wetting agent disclosed in Fu would not have been suitable in Swanson.

On this record, we affirm the Examiner's § 103(a) rejection of claims 8 and 9 over Swanson in view of Yasutomi and Fu.

#### DECISION

The Examiner's decision 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).

ORDER

AFFIRMED