

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent of: Dae Young Kim, et al.
U.S. Patent No.: 10,480,090 Attorney Docket No. 57533-0001IP1
Issue Date: November 19, 2019
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Filing Date: Oct. 27, 2016
Title: ELECTROLYTIC COPPER FOIL, CURRENT COLLECTOR
COMPRISING THE SAME, ELECTRODE COMPRISING THE
SAME, SECONDARY BATTERY COMPRISING THE
SAME, AND METHOD FOR MANUFACTURING THE SAME

DECLARATION OF DR. MICHAEL RANDALL

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I. QUALIFICATIONS AND BACKGROUND INFORMATION

1. My education and experience are described more fully in the attached curriculum vitae (Appendix A). For ease of reference, I have highlighted certain information below.

2. I received my PhD in Materials Science and Engineering from the University of Florida in 1993 after obtaining an MS in Materials Science and Engineering, and a BS in Ceramic Engineering, minoring in chemistry. I have worked in the materials and electronic materials industries since 1983 with numerous companies (both large and small) that operate in these industries. I have extensive experience with electronic materials and devices, including electronic materials and components, and including battery materials. During my career, I have gained experience in manufacturing techniques (both additive and subtractive), including coatings (both thin and thick film), including electroplating, and including the electroplating of copper. I have also used material analysis tools extensively, including but not limited to, surface analysis, including surface metrology (contact and non-contact). I have also gained experience in the area of materials analysis techniques, including X-Ray diffraction (XRD), as well as with thermal analysis tools such as differential thermal analysis (DTA), thermal mechanical analysis (TMA) and the like. During my career, I have also gained experience with chemical analytical tools and techniques for the analysis of surface

and bulk chemistries, including chemical analysis techniques such as atomic absorption spectroscopy (AA) and the like. Further, I have gained experience with mechanical characterization techniques such as tensile testing, film adhesion testing and the like, as well as numerous other analytical techniques that are pertinent to the electronic devices and materials industries as detailed in my CV.

3. I am currently President and CEO at Almegacy, LLC, an engineering consulting firm. I am being compensated for my work as an expert on an hourly basis. My compensation is not dependent on the outcome of these proceedings or the content of my opinions.

4. I have been retained on behalf of Solus Advanced Materials Co., Ltd. to offer technical opinions relating to U.S. Patent No. 10,480,090 (“the ’090 Patent”) and prior art references relating to its subject matter. I have reviewed the ’090 Patent, and relevant excerpts of the prosecution history of the ’090 Patent. I have also reviewed the following references:

SOLUS-1001 U.S. Patent No. 10,480,090 (“the ’090 Patent”)

SOLUS-1002 Excerpts from Prosecution History of the ’090 Patent (“the Prosecution History”)

SOLUS-1004 U.S. Patent Pub. No. 2013/0108922 (“Shinozaki”)

SOLUS-1005 C. P. Fabian et al., *Assessment of activated polyacrylamide and guar as organic additives in copper electrodeposition*,” Hydrometallurgy 86 (2007) 44-55 (“Fabian”)

- SOLUS-1006 Reserved
- SOLUS-1007 U.S. Patent Pub. No. 2009/0047539 (“Dobashi”)
- SOLUS-1008 U.S. Patent Pub. No. 2006/0191798 (“Sano”)
- SOLUS-1009 U.S. Patent Pub. No. 5834140 (“Wolski”)
- SOLUS-1010 WO Patent Pub. No. WO2015/102323 (“Choi”)
- SOLUS-1011 Certified English Translation of WO2015/102323 and Translator’s Declaration (“Choi”)
- SOLUS-1012 U.S. Patent Pub. No. 2013/0108887 (“Kim”)
- SOLUS-1013 Korean Patent Pub. No. 2012/0003485A (“Toshio”)
- SOLUS-1014 Certified English Translation of KR 2012/0003485A and Translator’s Declaration (“Toshio”)
- SOLUS-1015 Michael B. Griesi, *Characterization of Electrodeposited Copper Foil Surface Roughness for Accurate Conductor Power Loss Modeling*, UNIV. S.C., Dec., 2014 (“Griesi”)
- SOLUS-1016 Gadelmawla, *Roughness parameters*, Journals of Materials Processing Technology 123 (2002) 133-145 (“Gadelmawla”)
- SOLUS-1017 *Surface roughness – Definitions and designation*, Japanese Industrial Standard (JIS) B 0601-1994 (“JIS Standard 1994”)
- SOLUS-1018 *Geometrical Product Specifications (GPS) – Surface texture: Profile method – Terms, definitions and surface texture parameters* (“JIS Standard 2001”)
- SOLUS-1019 *Geometrical Product Specifications (GPS) – Surface texture: Profile method – Terms, definitions and surface texture*

- parameters*, DIN EN ISO 4287 (“DIN Standard”)
- SOLUS-1020 *Operating Instructions MarSurf M 300 + RD 18*, Mahr GmbH, 2008 (“MarSurf M300 instruction manual”)
- SOLUS-1021 *Surface Texture (Surface Roughness, Waviness, And Lay)*, ASME B 46.1 (2009) (“ASME Standard”)
- SOLUS-1022 Japanese Patent Pub. No. JP 2007/217787 (“Matsuda”)
- SOLUS-1023 *Surface Roughness Measurement-Parameters*, Olympus, <https://www.olympus-ims.com/en/metrology/surface-roughness-measurement-portal/parameters/> (“Olympus”)
- SOLUS-1024 B. Bhushan, *Surface roughness analysis and measurement techniques* (2000) (“Bhushan”)
- SOLUS-1025 U.S. Patent Pub. No. 2014/0302281 (“Yacovone”)
- SOLUS-1026 Certified English Translation of JP 2007/217787 and Translator’s Declaration (“Matsuda”)
- SOLUS-1027-1028 Reserved
- SOLUS-1029 Michael Griesi, *Electrodeposited Copper Foil Surface Characterization for Accurate Conductor Loss Modeling*, DesignCon 2015 Proceedings, January, 2015 (“Griesi Presentation”)
- SOLUS-1030 U.S. Patent Pub. No. US20140342178A1 (“Saito”)
- SOLUS-1031 U.S. Patent Pub. No. US20100038115A1 (“Matsuda 115”)
- SOLUS-1032 Japanese Patent Pub. No. JP 2010/103061A (“Kodaira”)
- SOLUS-1033 Japanese Patent Pub. No. JP 2014/065933A (“Yoshiki”)

- SOLUS-1034 Korean Patent Pub. No. KR 2014/0078883A and Certified English Translation of Korean Patent Pub. No. KR 2014/0078883A (“Lee”)
- SOLUS-1035 Frederick A. Lowenheim, *Modern Electroplating*, John Wiley & Sons, 1974 (“Lowenheim”)
- SOLUS-1036 *Measurement of roughness average Ra and peak count RPc on metallic flat products*, DIN EN 10049:2014-03 (“DIN EN 10049 (2014) Standard”)
- SOLUS-1037 September 11, 2024 Email from *SK nexilis* Counsel

5. I have also reviewed various supporting references and other documentation.

6. Counsel has informed me that I should consider these materials through the lens of one of ordinary skill in the art related to the '090 Patent at the time of the priority date of the '090 Patent, and I have done so during my review of these materials. Counsel has informed me that the priority date to which the '090 Patent is entitled priority (“Critical Date”) can be no earlier than June 24, 2015. I have therefore used that Critical Date in my analysis below.

7. I have no financial interest in the parties or in the outcome of this proceeding. I am being compensated for my work as an expert on an hourly basis.

My compensation is not dependent on the outcome of these proceedings or the content of my opinions.

8. My opinions, as explained below, are based on my education, experience, and expertise in the fields relating to the '090 Patent. Unless otherwise stated, my testimony below refers to the knowledge of one of ordinary skill in the art as of the Critical Date, or before. Any figures that appear within this document have been prepared with the assistance of Counsel and reflect my understanding of the '090 Patent and the prior art discussed below.

II. OVERVIEW OF CONCLUSIONS FORMED

9. This declaration explains the conclusions that I have formed based on my analysis. To summarize those conclusions, based upon my knowledge and experience and my review of the prior art publications listed above, I believe that:

- Claims 1-4, 7, 8, and 10 are obvious over Shinozaki;
- Claims 5, 6, 9, and 11 are obvious over Shinozaki in view of Toshio (or Kim);
- Claims 1-4, 7, 8, and 10 are obvious over Sano in view of Griesi;
- Claims 5, 6, 9, and 11 are obvious over Sano in view of Griesi and Toshio (or Kim); and
- Claims 1-11 are obvious over Dobashi

III. LEVEL OF ORDINARY SKILL IN THE ART

10. In my opinion, person (one) of ordinary skill in the art (“POSITA”) relating to, and at the time of, the invention of the ’090 Patent would have had at least an undergraduate degree in materials science, chemical engineering, electrical engineering, or related field, or equivalent knowledge, training, or experience, with at least two years of experience working on the development of materials or components for electronic devices such as batteries. Additional education, such as a graduate degree, could compensate for less work experience, and additional work experience could compensate for less formal education.

IV. SUMMARY OF THE ’090 PATENT

11. The ’090 Patent relates to an electrolytic copper foil that “can secure secondary batteries with high capacity maintenance,” where the electrolytic copper foil includes a first surface and a second surface opposite to the first surface, each surface having “a peak count roughness R_{pc} of 10 to 100.” SOLUS-1001, Abstract. However, as I demonstrate here, such electrolytic copper foil with each of its two surfaces having the claimed peak count roughness, among other features, was well-known in the art at the time of filing of the ’090 Patent.

V. RELEVANT TECHNICAL ASPECTS

12. “Surface roughness evaluation is very important for many fundamental problems such as friction, contact deformation, heat and electric current conduction, tightness of contact joints and positional accuracy.” SOLUS-1016, 1¹. In particular, in the field of surface profilometry of copper foil used in secondary batteries or printed circuit boards, it was well within the skill of a POSITA to adjust surface roughness parameters of the copper foil to enhance adhesion, contact, or friction characteristics. Such surface roughness parameters can measure horizontal characteristics (e.g., peak spacing, number of peaks within surface measurement length) of the copper foil surface, vertical characteristics (e.g., peak height), or a combination of both.

13. Surface roughness parameters such as “Ra,” “Rz,” and “Rpc” correspond to measurements of surface roughness obtained through profilometric analysis of a sample. In a typical profilometry measurement, a contacting probe is scanned across the surface of the sample, and the vertical deflection of the probe indicates the underlying topography.

14. Rz or Rzjis is often referred to as a 10-point mean (average) roughness according to, among other standards, Japanese Industrial Standards (JIS)

¹ Citations refer to page number of the PDF document.

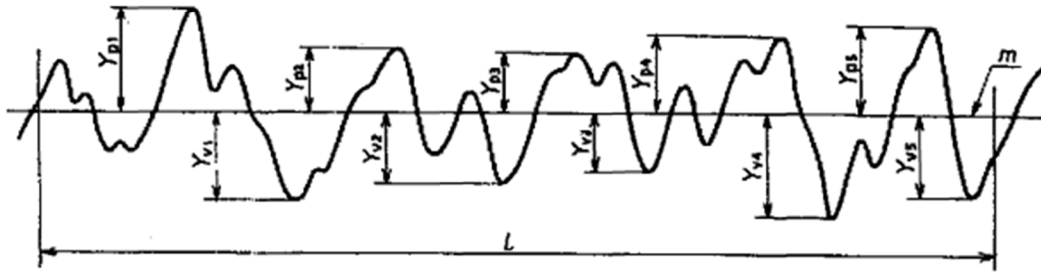
B 0601 standards. For example, such R_z , R_{zj} , or the 10-point mean (average) roughness represents the sum of the absolute values of the five highest peaks and the absolute values of the five lowest valleys of a surface (e.g., copper foil surface) over a reference length (l), divided by 5. SOLUS-1017, 13, FIG. 4 (reproduced below); SOLUS-1018, 24-25.

$$R_z = \frac{|Y_{p1} + Y_{p2} + Y_{p3} + Y_{p4} + Y_{p5}| + |Y_{v1} + Y_{v2} + Y_{v3} + Y_{v4} + Y_{v5}|}{5}$$

where, $Y_{p1}, Y_{p2}, Y_{p3}, Y_{p4}, Y_{p5}$: altitudes of the heights of five highest profile peaks of the sampled portion corresponding to the reference length l

$Y_{v1}, Y_{v2}, Y_{v3}, Y_{v4}, Y_{v5}$: altitudes of the depths of five deepest profile valleys of the sampled portion corresponding to the reference length l

Fig. 4. Determination of R_z



SOLUS-1017, 13, FIG. 4

15. Further, as indicated in Table 5 (reproduced below) of the same, the average of 5 of these reference lengths (l) are used to compute R_z over the evaluation length (l_n). And in the case where R_z is $\geq 0.5 \mu\text{m}$ and $\leq 10.0 \mu\text{m}$, the above equation is used with 5 reference lengths (l), each of 0.8 mm, to compute R_z

for the evaluation length (l_n) of 4 mm (4,000 μm). SOLUS-1017, 14, Table 5 (reproduced below, annotated).

Table 5. Standard values of reference lengths and evaluation lengths in determining R_z

Range of R_z (μm)		Reference length l (mm)	Evaluation length l_n (mm)
Exceeding	Max.		
(0.025)	0.10	0.08	0.4
0.10	0.50	0.25	1.25
0.50	10.0	0.8	4
10.0	50.0	2.5	12.5
50.0	200.0	8	40

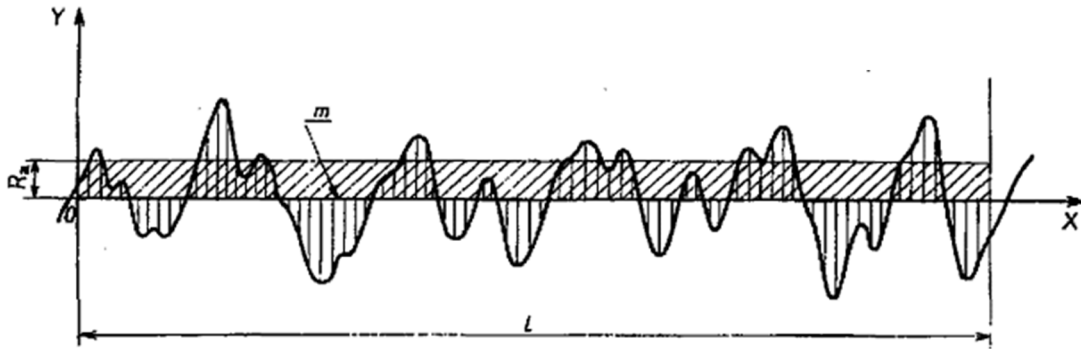
SOLUS-1017, Table 5

16. R_a also measures vertical characteristics of the copper foil surface. For example, R_a represents the average roughness of a surface, calculated as the mean absolute deviation of the surface profile from the central mean line over a specified sampling length according to, among other standards, Japanese Industrial Standard (JIS) B 0601. SOLUS-1016, 1-2; SOLUS-1017, 7. For instance, as shown below, mathematically, R_a is calculated by integrating the absolute value of the height of the assessed profile “ $f(x)$ ” over a reference length (l) and dividing by the reference length. SOLUS-1017, 7, FIG. 2 (reproduced below).

$$R_a = \frac{1}{l} \int_0^l |f(x)| dx$$

where, l : reference length

Fig. 2. Determination of R_a



SOLUS-1017, 7, FIG. 2

17. R_{pc} is explained or recited in the '090 Patent as “the number of effective peaks which rise above an upper criteria line of 0.5 μm per unit sampling length of 4 mm in a surface roughness profile obtained according to steel iron test schedule (SEP 1940), and there is at least one valley deeper than a lower criteria line of -0.5 μm between adjacent ones of the effective peaks.” SOLUS-1001, claim 1. As will be explained further below regarding the prior art analysis section, R_{pc} is a well-recognized surface roughness parameter shared among various surface roughness measurement standards, reflecting, among other things, the number of peak count (or “effective peaks”) based on (i) an “upper criteria line” and (ii) a “lower criteria line.” *See id.* As such, R_{pc} measures horizontal characteristics (e.g., number of peaks within the surface measurement length or evaluation length) of the copper foil surface. Further, because R_{pc} measures the

number of peaks that satisfy peak height thresholds (e.g., upper and lower minimum criteria lines), R_{pc} can also be correlated with certain vertical characteristics. In some instances, as will be explained further below in the prior art analysis section, a POSITA would have known that controlling R_{pc} can be correlated with controlling height-related parameters, such as R_a . For example, by controlling R_{pc} based on its peak height threshold (which can be similar to a height-related parameter, such as R_a), a POSITA can obtain certain surface profile characteristics, such as consistency or distribution of peaks that meet the threshold height. This consistency or uniformity of peaks, as determined by R_{pc} , is related to enhancing the adhesion properties (e.g., surface characteristics that improve adhesion (and/or consistency of adhesion) between the foil and the active material) of the electrolytic copper foil. This is similar to how R_a can be used to achieve the same objective of improving adhesion between the current collector and the active material of the secondary battery.

18. In a copper electrolytic deposition process, the surface properties of the “shiny” side of the copper foil closely replicate the surface finish of the cathode drum on which it is formed. By adjusting the surface finish of the drum, the properties of the copper foil can be precisely controlled. The shiny side of the copper foil, which contacts the drum, becomes a mirror image of the drum's surface during the deposition process. Because of this, it was well within the skill

of a POSITA to achieve arbitrary or near-arbitrary shiny-side profiles (e.g., roughness characteristics such as Ra, Rz, and Rpc) by causing the surface of the cathode drum to have a mirrored version of that profile. For example, a POSITA could select a suitable polishing grit and polish the drum with that grit to achieve targeted shiny-side roughness characteristics. As another example, as described in prior art, structures on the cathode drum surface could be fabricated with particular spacings and depths/heights to cause corresponding shiny side features to have the same spacings and heights/depths. *See generally* SOLUS-1034; SOLUS-1007, [0055] (“the shiny side [] has a mirror shape of the surface of a rotating cathode polished”); SOLUS-1008, [0005] (“since the gloss surface [e.g. shiny side] copies a flat shape of a cathode drum surface...”). As such, some aspects of the following discussion will be based on the finding that a POSITA would have had a reasonable expectation of success in achieving targeted shiny side profile characteristics, based on the foregoing discussion and the teachings of the art discussed below.

VI. CLAIM INTERPRETATION

19. I understand that, for purposes of my analysis in this *inter partes* review proceeding, the terms appearing in the patent claims should be interpreted “using the same claim construction standard that would be used to construe the claim in a civil action under 35 U.S.C. 283(b)...” 37 C.F.R. § 42.100(b). In that

regard, I understand that the best indicator of claim meaning is its usage in the context of the patent specification as understood by a POSITA. I further understand that the words of the claims should be given their plain meaning unless that meaning is inconsistent with the patent specification or the patent's history of examination before the Patent Office. I also understand that the words of the claims should be interpreted as they would have been interpreted by a POSITA at the time of the invention was made.

VII. PRIOR ART ANALYSIS

A. [GROUND 1A] – CLAIMS 1-4, 7, 8, and 10 ARE OBVIOUS OVER SHINOZAKI

20. It is my opinion that a POSITA would have found claims 1-4, 7, 8, and 10 to be obvious over Shinozaki, as I discuss in the following sections.

Overview of Shinozaki

21. Shinozaki describes a current collector for use in secondary batteries. SOLUS-1004, Abstract (“A lithium ion secondary battery, which uses a negative electrode wherein an active material is deposited on a collector”). In particular, Shinozaki focuses on providing a current collector that is “characterized in that no wrinkles are formed on the collector, the collector does not fracture, the adhesion between the active material and the collector is high, and stable performance can be maintained for a long period of time.” *Id.*, Abstract.

22. More specifically, Shinozaki describes an electrolytic copper foil for the current collector, in which a “surface-roughened layer of copper or copper alloy particles having a particle diameter of 0.1-3 μm is formed on both surfaces of an untreated copper foil by roughening treatment by means of electrolysis, and the surface-roughened layers on both surfaces have a *surface roughness Rz of 1.0-5 μm* and a *surface roughness Ra of 0.25-0.7 μm* , with the *Rz difference* between the front and back surfaces being *within 3 μm* and the *Ra differences* between the front and back surfaces being *within 0.3 μm* .” SOLUS-1004, Abstract, [0029], [0031], [0032].

23. In the above, each of “Ra” and “Rz” is a measure of surface roughness obtained by profilometric analysis of a sample. In a typical profilometry measurement, a contacting probe is scanned across the surface of a sample. The vertical deflection of the probe is indicative of the underlying topography of the sample.

24. Further, Shinozaki describes that “the surface roughnesses Rz and Ra are the 10-point mean (average) roughness and arithmetical mean (average) roughness prescribed in the Japanese Industrial Standard (JIS B0601-1994).” SOLUS-1004, [0058].

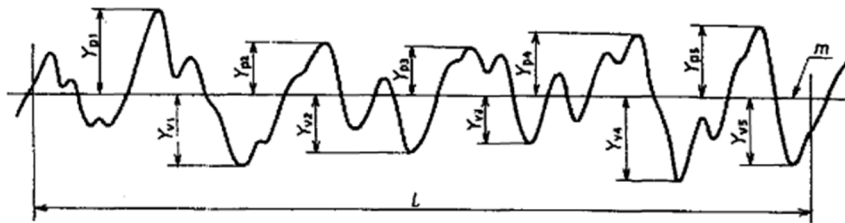
25. In simple terms, above-noted Rz (e.g., 10-point mean (average) roughness) represents the sum of the absolute values of the five highest peaks and the absolute values of the five lowest valleys of a surface (e.g., copper foil surface) over a reference length (l), divided by 5. SOLUS-1017, 13-14, FIG. 4 (reproduced below); SOLUS-1018, 24-25.

$$R_z = \frac{|Y_{p1} + Y_{p2} + Y_{p3} + Y_{p4} + Y_{p5}| + |Y_{v1} + Y_{v2} + Y_{v3} + Y_{v4} + Y_{v5}|}{5}$$

where, $Y_{p1}, Y_{p2}, Y_{p3}, Y_{p4}, Y_{p5}$: altitudes of the heights of five highest profile peaks of the sampled portion corresponding to the reference length l

$Y_{v1}, Y_{v2}, Y_{v3}, Y_{v4}, Y_{v5}$: altitudes of the depths of five deepest profile valleys of the sampled portion corresponding to the reference length l

Fig. 4. Determination of R_z



SOLUS-1017, 13, FIG. 4

And the average of 5 of these reference lengths (l) are used to compute Rz over the evaluation length (l_n). In the case where Rz is $\geq 0.5 \mu\text{m}$ and $\leq 10.0 \mu\text{m}$, the above equation is used with 5 reference lengths (l), each of 0.8 mm, to compute Rz for the evaluation length (l_n) of 4 mm (4,000 μm). SOLUS-1017, 14, Table 5 (reproduced below, annotated).

Table 5. Standard values of reference lengths and evaluation lengths in determining R_z

Range of R_z (μm)		Reference length l (mm)	Evaluation length l_n (mm)
Exceeding	Max.		
(0.025)	0.10	0.08	0.4
0.10	0.50	0.25	1.25
0.50	10.0	0.8	4
10.0	50.0	2.5	12.5
50.0	200.0	8	40

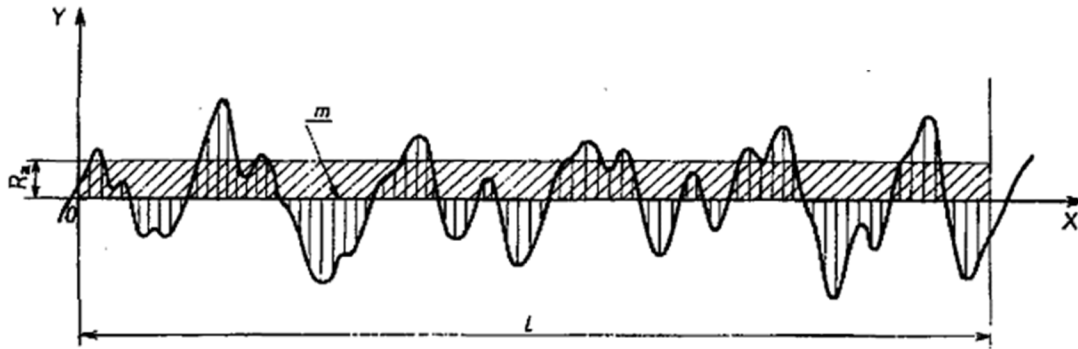
SOLUS-1017, Table 5

26. Further, in simple terms, above-noted R_a represents the average roughness of a surface, calculated as the mean absolute deviation of the surface profile from the central mean line over a specified sampling length. SOLUS-1016, 1-2; SOLUS-1017, 7. For instance, as shown below, mathematically, R_a is calculated by integrating the absolute value of the height of the assessed profile “ $f(x)$ ” over a reference length (l) and dividing by the reference length. SOLUS-1017, 7, FIG. 2 (reproduced below).

$$R_a = \frac{1}{l} \int_0^l |f(x)| dx$$

where, l : reference length

Fig. 2. Determination of R_a



SOLUS-1017, 7, FIG. 2

1. Claim-by-Claim Analysis

(i) Claim 1

[1pre] An electrolytic copper foil for a secondary battery, the electrolytic copper foil comprising:

27. To the extent the preamble is deemed to be limiting, Shinozaki renders it obvious. For example, Shinozaki specifically discloses “an electrolytic copper foil for a lithium ion secondary battery.” SOLUS-1004, Abstract, [0041] (“the lithium ion secondary battery of the present invention uses the above electrolytic copper foil for the above negative electrode of the battery”).

[1a] a first surface; and

[1b] a second surface opposite to the first surface,

28. Shinozaki renders obvious [1a]-[1b]. For example, Shinozaki discloses an “electrolytic copper foil which comprises an untreated copper foil, on the *both front and back surfaces*,” which correspond to the claimed first surface and second surface opposite to the first surface. SOLUS-1004, [0031].

[1c] wherein each of the first and second surfaces has a peak count roughness R_{pc} of 10 to 100,

[1d] wherein the peak count roughness R_{pc} of each of the first and second surfaces is an average of peak count roughness R_{pc} values measured at randomly-selected three points,

[1e] the peak count roughness R_{pc} of each point is the number of effective peaks which rise above an upper criteria line of 0.5 μm per unit sampling length of 4 mm in a surface roughness profile obtained according to steel iron test schedule (SEP 1940), and there is at least one valley deeper than a lower criteria line of -0.5 μm between adjacent ones of the effective peaks.

29. As detailed below, Shinozaki renders obvious [1c]-[1e].

1. R_{pc} (peak count roughness) is a well-recognized measurement parameter shared among various standards, reflecting the number of peak counts (or “effective peaks”) based on (i) an “upper criteria line” and (ii) a “lower criteria line” per (iii) “unit sampling length”

30. First, various prior art describes that different surface measurement standards, such as ASME B46.1 (1985) and SEP 1940, share the same definition of R_{pc} as mentioned in the claim language of [1e]. See SOLUS-1025, FIG. 6 (reproduced below), [0050]; SOLUS-1020, 41. For example, this is evidenced at

least by Yacovone, which states that “[a]nother parameter used to describe the polymer interlayer sheet Surface is roughness peak count (Rpc), which is a two dimensional surface measurement parameter that was measured by a Mahr Perthometer S3P device according to the standards **SEP 1940:01.92** and **ANSI/ASME B46.1** (1985). For the measurements, the following set points on the device were used: Profile (R): . . . Sampling Length (LC): 2.5 mm; Lower Boundary (C2): -0.5 μm from mean line (M); and Upper Boundary (C1): 0.5 μm from mean line (M). The peak count is dependent on the profile type, and an upper and lower boundary (C1 and C2). The peak count is the number or counts of roughness profile elements exceeding the lower boundary line (C2), and the upper boundary line (C1), immediately afterwards as shown in the FIG. 6 [described below].” SOLUS-1025, [0050], FIG. 6 (reproduced below). For example, FIG. 6 of Yacovone explains the identical concept of Rpc, as disclosed in FIG. 2 of the ’090 Patent. SOLUS-1001, FIG. 2 (reproduced below).

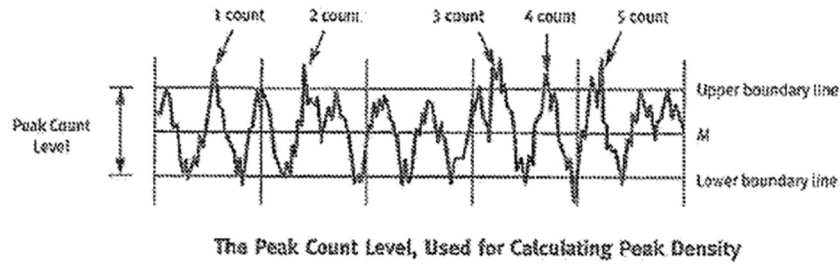
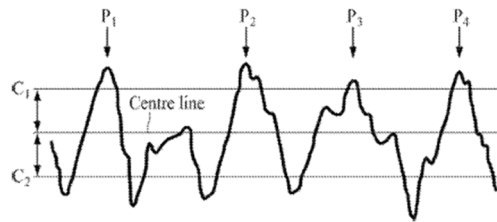


FIGURE 6
SOLUS-1025, FIG. 6

FIG. 2

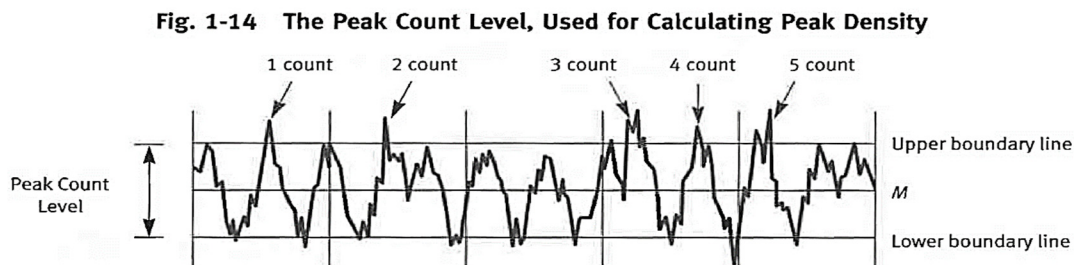


SOLUS-1001, FIG. 2

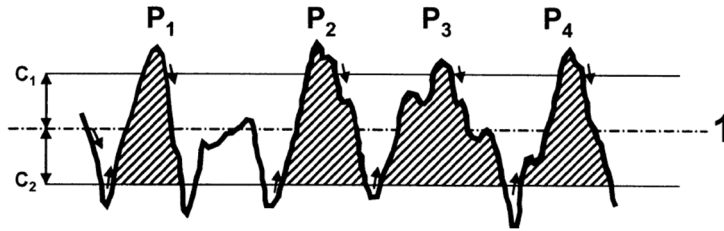
31. Second, an instruction manual for the surface profile measurement equipment (MarSurf M300), from which the '090 Patent derives R_{pc} data, describes that this R_{pc} definition is shared by various measurement standards. SOLUS-1001, 8:1-5. For example, the specification of the '090 Patent states that “the peak count roughness R_{pc} of the shiny surface and matte surface of the electrolytic copper foils was measured using a MahrSurf M300 roughness tester available from Mahr company and results are shown in the following Table 1” and the MarSurf M300 instruction manual describes that R_{pc} is shared by a number of different surface roughness measurement standards including “EN 10049: 2005,

ASME B46. 1 2002; E DIN EN ISO 4287/A1: 2007-07 (D).” SOLUS-1001, 8:1-5, SOLUS-1020, 41.

32. Third, other measurement standards, such as ASME B46.1 (2009) and DIN EN 10049 (2014), provide the same definition of R_{pc} as recited in the claim language of [1e]. For instance, ASME B 46.1 (2009) refers to “peak density or “ P_c ” and describes that “the number of SAE peaks per unit length measured at a specified peak count level over the evaluation length,” in which “SAE peak” is defined as a “profile irregularity wherein the profile intersects consecutively a lower and an upper boundary line . . . located parallel to and equidistant from the profile mean line (see Fig. 1-14).” SOLUS-1021, 21-22, FIG. 1-14 (reproduced below). Further, for instance, DIN EN 10049 (2014) Standard refers to R_{pc} as “number of profile peaks over the full evaluation length l_m ,” where “the height discrimination is performed by consecutively intersecting a lower section line c_2 . . . and an upper section line c_1 . See Figure 3.” SOLUS-1036, 9, FIG. 3 (reproduced below).



SOLUS-1021, FIG. 1-14



SOLUS-1036, FIG. 3

33. Accordingly, R_{pc} (peak count roughness), as claimed in the '090 Patent, is a well-recognized measurement parameter, shared among various standards.²

2. R_{pc} can be obtained from other surface roughness parameters such as R_{sm} or S_m

34. First, a measurement standard (DIN EN ISO 4287) known to share the same definition of R_{pc} as claimed describes that R_{pc} and R_{sm} are inversely related

² However, it is my opinion that the '090 Patent provides no substantive discussion of what it means to obtain a surface roughness profile “according to steel iron test schedule (SEP 1940).” Nevertheless, my application of prior art in this declaration is consistent with (i) the description of R_{pc} in the '090 Patent and (ii) Patent Owner’s allegation of infringement before the district court, where I have been informed by Counsel that Patent Owner has equated SEP 1940 to DIN EN 10049 (2014). See SOLUS-1037.

to each other and thus can be converted. For instance, $R_{pc} = L / R_{sm}$, where L is a “reference length” (e.g., “unit sampling length of 4 mm” recited in [1e]) and R_{sm} is a “mean value of the profile element widths X_s .” See SOLUS-1019, 20-21, FIG. 10 (reproduced below).

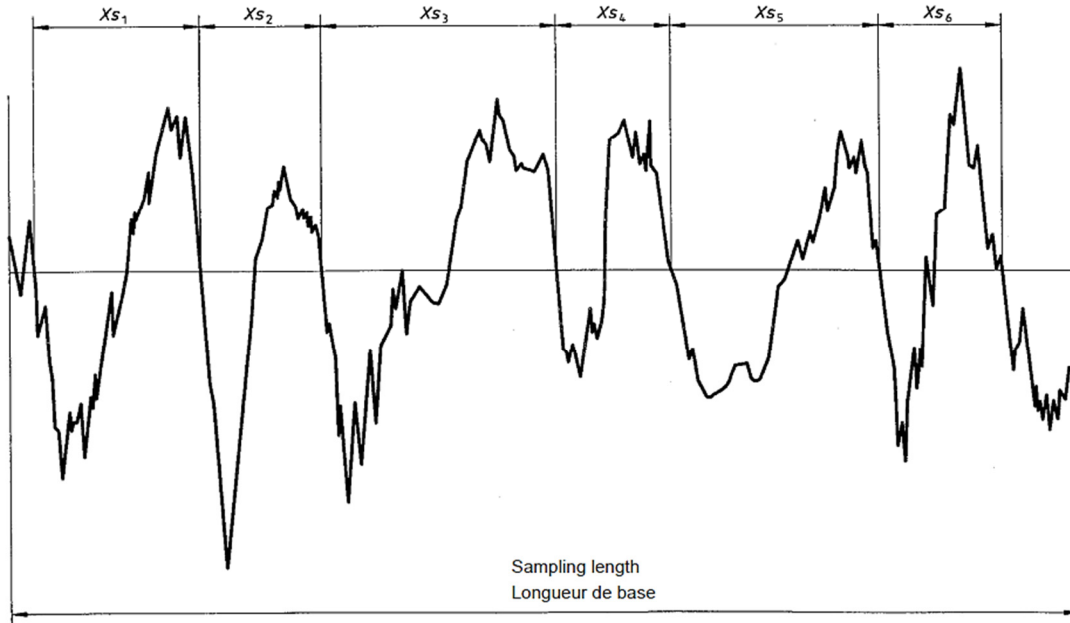


Figure 10 — Width of profile elements
Figure 10 — Largeur des éléments du profil

SOLUS-1019, FIG. 10

35. As such, [1] R_{sm} represents the average distance between pairs of consecutive peaks and valleys (exceeding upper and lower height discrimination criteria respectively) on a surface, and [2] dividing the sampling length by R_{sm} gives the number of these peak-valley pairs within that length because it measures how many average-width segments fit into the length.

36. Second, the roughness tester equipment used in the '090 Patent further confirms that R_{pc} can be converted from R_{sm} , as described in DIN EN ISO 4287. For instance, MahrSurf M300 equipment used in the '090 Patent describes that R_{pc} corresponds to a “[n]umber of profile elements (see R_{sm}) per cm (or per inch) which first exceed the set upper intersection line C1 and then fall short of the lower C2,” where R_{sm} is “[m]ean width . . . of profile elements (formerly: groove spacing).” SOLUS-1020, 41.

37. Lastly, it is noted that R_{sm} is also known as S_m . The MahrSurf M300 equipment of the '090 Patent describes that R_{sm} is shared among different measurement standards, including “JIS B 0601.” SOLUS-1020, 41. According to the JIS B 0601 standard, R_{sm} equates to S_m .³ SOLUS-1017, 16; SOLUS-1018, 21; SOLUS-1023. In the relationships illustrated below, $n = m$ and $S_{mi} = X_{Si}$ as per their respective definitions.

³ “ S_m shall be . . . the sum of the lengths of mean lines corresponding to one of the profile peaks and one profile valley adjacent to it (hereafter referred to as ‘spacing of profile irregularities’) . . . the arithmetical mean value of many spacings of these irregularities [e.g., within a reference length].” SOLUS-1017, 16, FIG. 5.

$$S_m = \frac{1}{n} \sum_{i=1}^n S_{mi}$$

where, S_{mi} : spacing of irregularities
 n : number of spacings of irregularity lying within the reference length

PSm, RSm, WSm
mean value of the profile element widths Xs within a sampling length

$$PSm, RSm, WSm = \frac{1}{m} \sum_{i=1}^m Xs_i$$

38. Therefore, R_{pc} can be obtained from other surface roughness parameters, such as R_{sm} or S_m .

3. Shinozaki discloses S_m values that correspond to R_{pc} values falling within the claimed range of “10 to 100”

39. As described above, Shinozaki describes an electrolytic copper foil that can enhance adhesion of current collector and active material, and attributes such adhesion to the following surface roughness characteristics:

[1] 10-point mean roughness R_z of 1.0 – 5 μm ;

[2] R_a of 0.25-0.7 μm ; and

[3] Both surfaces (matte surface and shiny surface) of electrolytic copper foil exhibiting similar roughness characteristics (e.g., similar R_z and similar R_a).

SOLUS-1004, Abstract, see [0029], [0031], [0032], [0073], [0074].

Moreover, Shinozaki discloses, example data (e.g., from Working Example 6) of Rz at 2.8 μm , Ra at 0.46 μm , and Sm (or Rsm) at 50.00 μm for the shiny surface of an example copper electrolytic foil. SOLUS-1004, Table 3, Work. Ex. 6, [0116].

40. There are at least two approaches which can be used to calculate R_{pc} from the example data (e.g., from Working Example 6) and/or other data listed in Shinozaki's Table 3. SOLUS-1004, Table 3. Based on these two approaches, it is possible to [1] confirm that the Shinozaki's example data (e.g., from Working Example 6) exhibits R_{pc} falling within the claimed range of "R_{pc} of 10 to 100" and [2] present other data of Shinozaki that exhibit R_{pc} values that also fall within the claimed range. I will explain these two approaches in more detail below.

41. First, R_{pc} can be approximated based on the Sm and Ra values disclosed in the example data of Shinozaki. For example, the Sm value of the example data (e.g., Working Example 6) of Shinozaki can be converted to the R_{pc} value of 40 by using its associated Ra value as a proxy for the upper and lower criteria lines of $\pm 0.5 \mu\text{m}$. More specifically, as described above, Sm (e.g., Sm of JIS B0601) can be converted to R_{pc} based on the following equation: $R_{pc} = L / Sm$. SOLUS-1019, 20-21; SOLUS-1018, 14, 21. Here, as the example data in Shinozaki do not specify upper and lower criteria lines, this Working Example 6 in Shinozaki yields $R_{pc} = (4 \text{ mm} \times 1000 \mu\text{m/mm}) / 50.00 \mu\text{m} = 4,000 \mu\text{m} / 50.00 \mu\text{m} = 80$ effective peaks, a maximum for Working Example 6. SOLUS-1004, Table 3.

However, because the claim requires “upper criteria line of $0.5\ \mu\text{m}$ ” and “lower criteria line of $-0.5\ \mu\text{m}$,” the R_{pc} value would be lower than maximum value of 80 for Shinozaki’s Working Example 6 as described below.

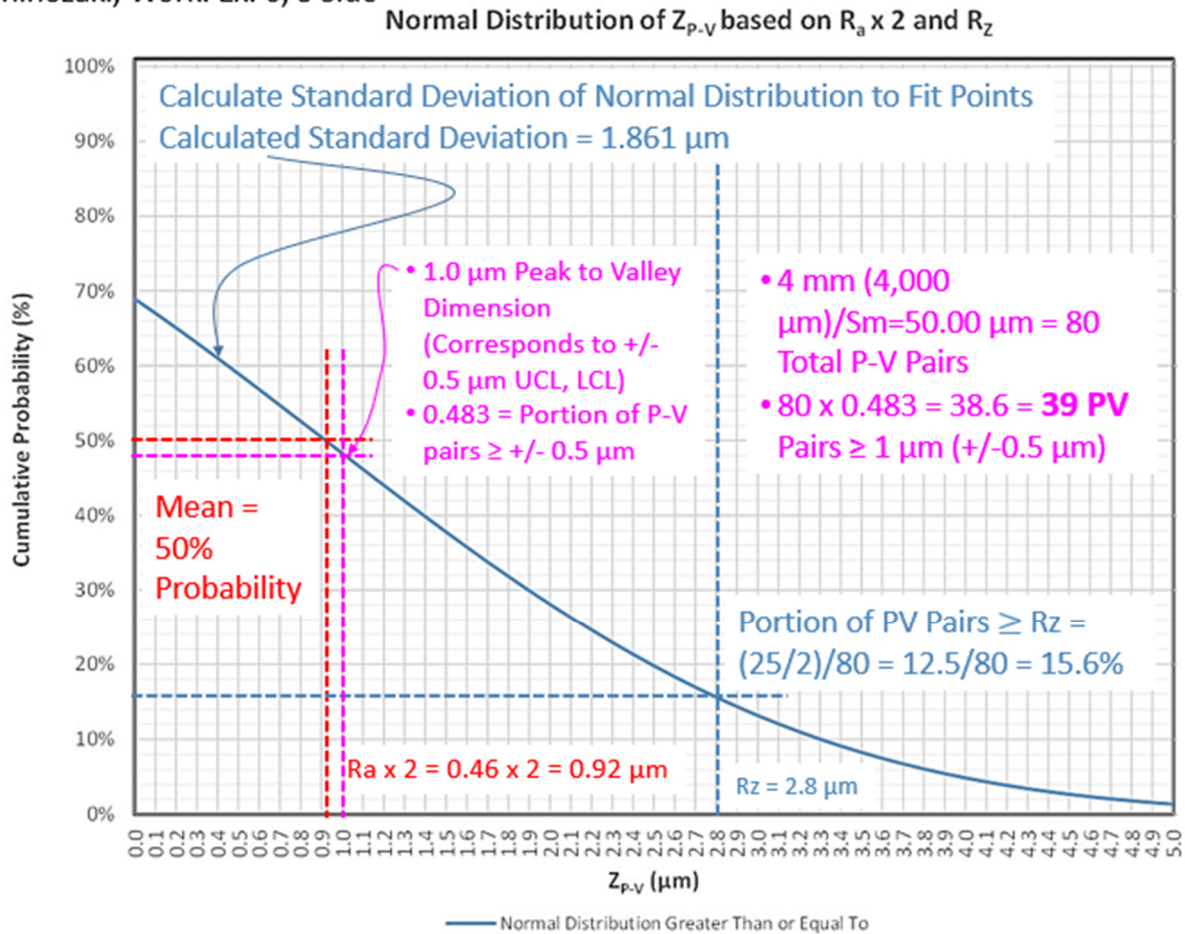
42. The R_a value of $0.46\ \mu\text{m}$ of Shinozaki’s Working Example 6 (which becomes $0.5\ \mu\text{m}$ when rounded to the number of significant figures disclosed in [1e] for upper and lower criteria) can then be used to estimate R_{pc} that satisfies the limitations regarding “upper criteria line of $0.5\ \mu\text{m}$ ” and “lower criteria line of $-0.5\ \mu\text{m}$ ” in [1e]. Here, R_a represents the average *absolute value* of the height deviation from the mean line of the surface over a specified sampling length. Therefore, the R_a value ($\approx 0.5\ \mu\text{m}$) can be used as a reliable proxy for the upper ($+0.5\ \mu\text{m}$) and the lower ($-0.5\ \mu\text{m}$) criteria lines in the case of Working Example 6 of Shinozaki. Thus, a POSITA would have known to estimate that approximately half of the peaks and valleys in Shinozaki’s example will rise above and fall below the R_a or upper/lower criteria lines of $\pm 0.5\ \mu\text{m}$. Thus, R_{pc} which was derived above (without considering the upper/lower criteria lines of $\pm 0.5\ \mu\text{m}$) would be halved when considering Working Example 6. For instance, now the calculation would yield $R_{pc} = (4,000\ \mu\text{m} / 50.00\ \mu\text{m}) \times 1/2 = 40$ effective peaks.

43. Further, a POSITA would have understood that these 40 effective peaks would not always have peaks and valleys which consecutively exceed (e.g., peak-valley-peak-valley consecutive sequence) these criteria, so the actual

Rpc is likely to be slightly less than, if not equal to, the Rpc estimate of 40 for Working Example 6. Accordingly, a POSITA would have understood that at least the shiny side of Working Example 6 of Shinozaki, for example would have Rpc of approximately 40, which falls within the claimed range of “10 to 100.”

44. Second, to help further validate the Rpc determination approaches above, Gaussian statistics can be used to estimate Rpc from the Sm, Ra, and Rz values disclosed in Shinozaki. For instance, “[t]he Gaussian (normal) distribution has become one of the mainstays of surface classification.” SOLUS- 1024, 4. Based on establishing respective Gaussian distributions, Table 3 of Shinozaki has been re-developed, and the Rpc of Working Example 6 is estimated to be 39 which agrees very closely with 40 above, and which falls within the claimed range of “10 to 100.”

45. To help illustrate, a simple Gaussian (normal) distribution of Table 3 of Shinozaki is shown below. Here, the x-axis represents peak-to-valley pair height (distance), and the y-axis represents the cumulative probability corresponding to the proportion of peak-valley pairs with height (distance) greater than or equal to the peak-to-valley pair height (distance) specified on the x-axis.



46. This normal distribution has been developed by at least performing the following steps:

[1] Multiplying R_a (average height of surface profile from the centerline) by 2 to calculate average peak-to-valley height (distance) of the surface profile, in which the average peak-to-valley height (distance) corresponds to the x-axis value (e.g., $0.92 \mu\text{m} = 2 \times 0.46 \mu\text{m}$ (R_a) for Shinozaki's Working Example 6) at y-axis value indicating 50% cumulative probability;

[2] Utilizing Rz value (average peak-to-valley height (distance) among the sum of absolute values of the five highest peaks and the absolute values of the five lowest valleys) as the x-axis value occupying lower end of the cumulative probability on the y-axis. The corresponding y-axis value is determined by calculating the proportion of half of Rz's 25 peak-valley pairs among the total number of peak-valley pairs. (Rz represents 5 peak-valley pairs over a 0.8 mm reference length, and [1e] specifies a "sampling length of 4 mm," which results in 25 pairs corresponding to Rz). Since Rz is an average value, approximately half of these 25 peak-valley pairs will have a peak-to-valley height (distance) greater than Rz, while the other half will have a height (distance) less than Rz. Accordingly, 12.5 peak-valley pairs correspond to the proportion of peak-to-valley height (distance) data points greater than or equal to Rz, occupying the lowest end of the cumulative probability on the y-axis; and

[3] Using two pairs of data points [1st pair ($R_a \times 2$, 50% cumulative probability) and 2nd pair (Rz, calculated cumulative probability)] to determine the associated standard deviation, and to establish the normal distribution.

47. Once the normal distribution is developed, a POSITA would be able to determine the cumulative probability (y-axis value) at the x-axis value of 1.0

μm , in which such cumulative probability represents the proportion of peak-valley pairs with height (distance) that rises above and falls below the upper and lower criteria lines of $\pm 0.5 \mu\text{m}$. Thereafter, R_{pc} (derived from S_m without considering the upper/lower criteria lines of $\pm 0.5 \mu\text{m}$) can be multiplied by the cumulative probability to determine R_{pc} (effective peaks, peak-valley pairs) that satisfies the upper and lower criteria lines of $\pm 0.5 \mu\text{m}$.

48. Here, I would like to expand more on the details regarding the rationale and steps involved in establishing this Gaussian (normal) distribution explained in the preceding paragraphs.

49. Initially, a POSITA would have used normal statistics in order to characterize the data disclosed in Shinozaki, in order to better understand the disclosed copper foils. A POSITA would have understood that the assumption of normality (e.g., that the surfaces disclosed in Shinozaki are characteristically random) was appropriate in the case of Shinozaki. This is because electrodeposited copper foils tend to have random features as a POSITA would have understood. This was also evidenced by, for example, a surface roughness profile of the disclosed untreated foil of Griesi as reproduced below. SOLUS-1015, 54; SOLUS-1029, 18-19.

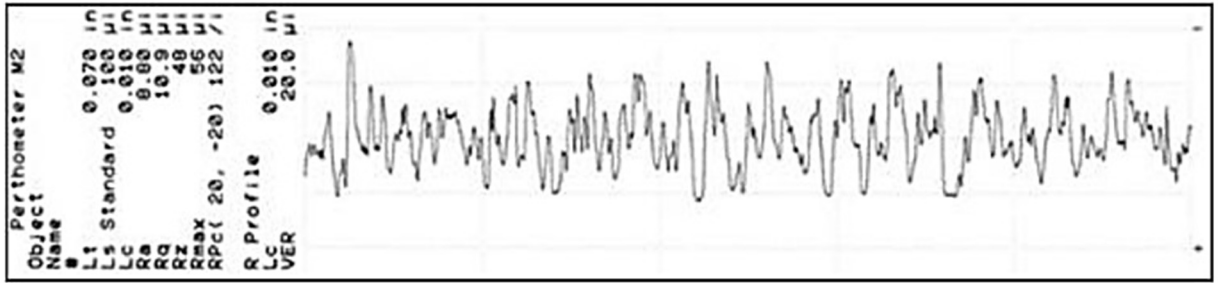
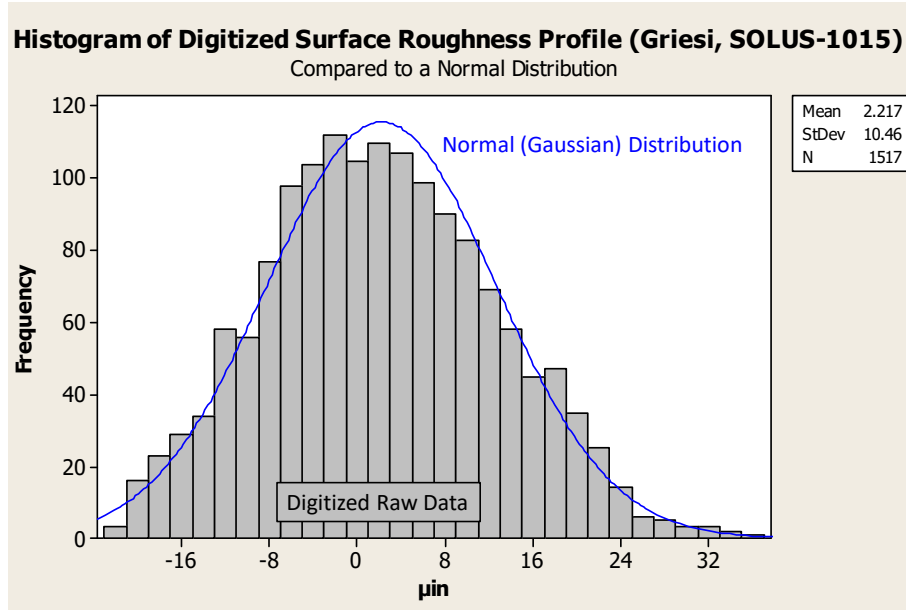


Figure 3.16 Printed Perthometer Surface Profile of Raw Untreated Copper Foil.

SOLUS-1015, FIG. 3.16; SOLUS-1029, 18-19⁴

50. The above graph was digitized, and a histogram of the raw data was produced as illustrated below. The illustration clearly shows that the above surface roughness profile data are well-fit by a normal distribution as would have been understood by a POSITA. Further, a POSITA would have understood that the surface roughened foils of Shinozaki, having been roughened on both sides via a process that is obviously random (e.g., stochastic) in nature, then covered with electroplating, that is also random in nature, would also be well-described by normal statistics.

⁴ Griesi Presentation includes an equivalent figure as FIG. 3.16 of Griesi



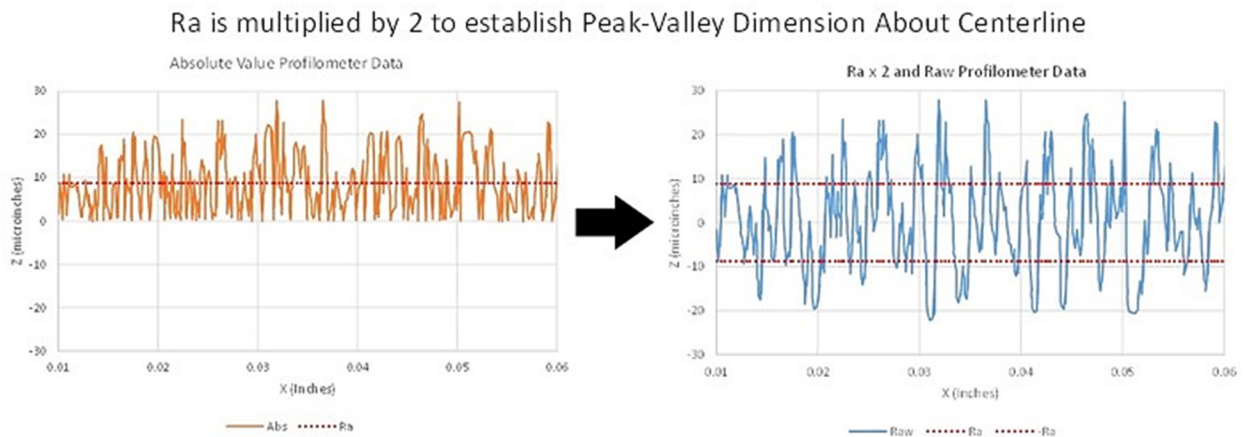
51. Again, as mentioned above, “[t]he Gaussian (normal) distribution has become one of the mainstays of surface classification.” SOLUS-1024, 4. This understanding has been (and still is) applied throughout the surface metrology community, as would be understood by a POSITA. The assumption of normality, and application of normal statistics (e.g., Gaussian distributions) to surface roughness data is, and was, common for surfaces created in a random (stochastic) manner. A POSITA would have known that “[s]urfaces that are formed by cumulative processes (such as peening, electropolishing, and lapping), in which the final shape of each region is the cumulative result of a large number of random discrete local events and irrespective of the distribution governing each individual event, will produce a cumulative effect that is governed by the Gaussian form. It is a direct consequence of the central limit theorem of statistical theory.” SOLUS-

1024, 4. Shinozaki's multiple random events in producing its treated surfaces would have involved the electrodeposition of the copper, in a random manner, onto a rotating cathode titanium drum having a random finish. The method used for electrodeposition of the copper (e.g., the chemistries, current densities, etc.) for creating the foils and thus both the S and the M surfaces also would have resulted in a surface having random roughness characteristics. Also, the addition of the plated powders would occur in random fashion, and the final cover plating of copper would be random in nature as well. Combined, a POSITA would have understood these random processes used to fabricate Shinozaki's roughened surfaces (on both sides) of the copper foil to be well-modeled using normal (Gaussian) statistics at least for the reasons detailed above.

52. A POSITA would have understood that, given the Ra, Rz and Sm values disclosed in Shinozaki (*See e.g.*, SOLUS-1004, Table 3), it would have been straightforward to calculate the number of peaks, and thus R_{pc} of said foils using the appropriate application of normal statistics. For example, as discussed above and herein, a POSITA would have understood that the total number of peaks can be calculated using 4,000 $\mu\text{m}/\text{Sm}$ based on Shinozaki's Table 3. SOLUS-1004, Table 3.

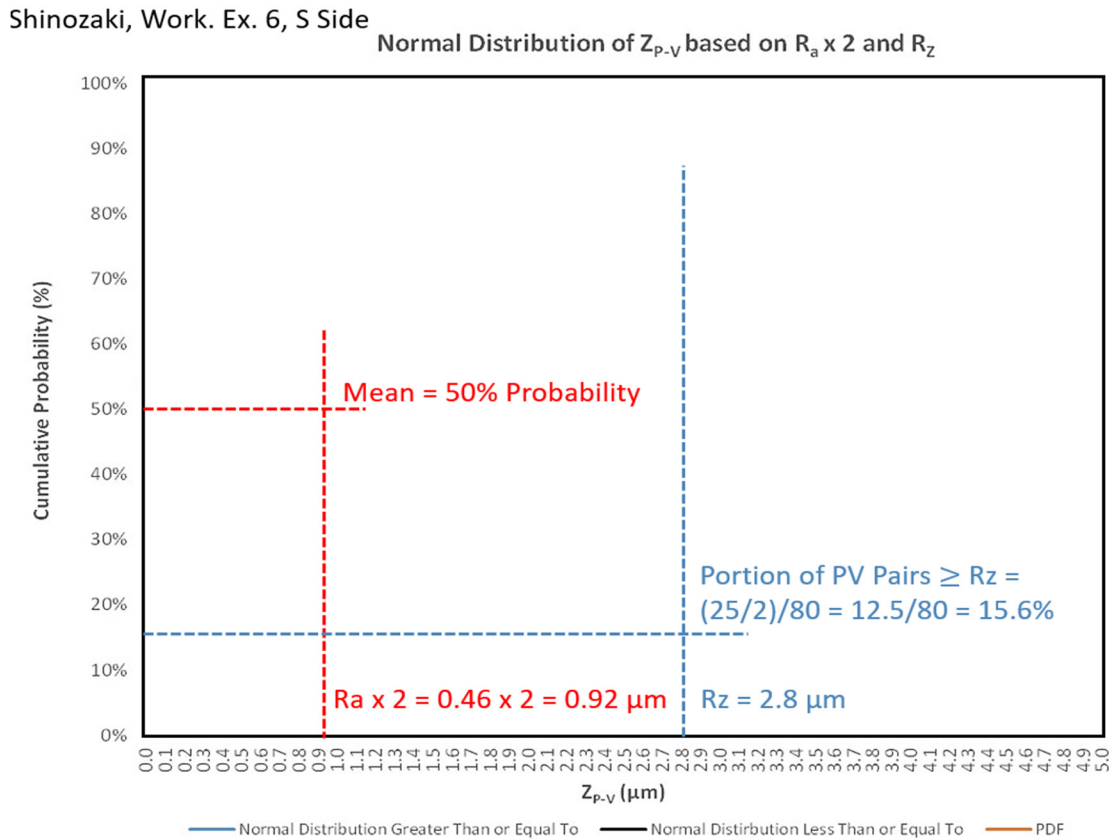
53. A POSITA would have understood that calculating the standard deviation of a normal (Gaussian) probability distribution would be straightforward

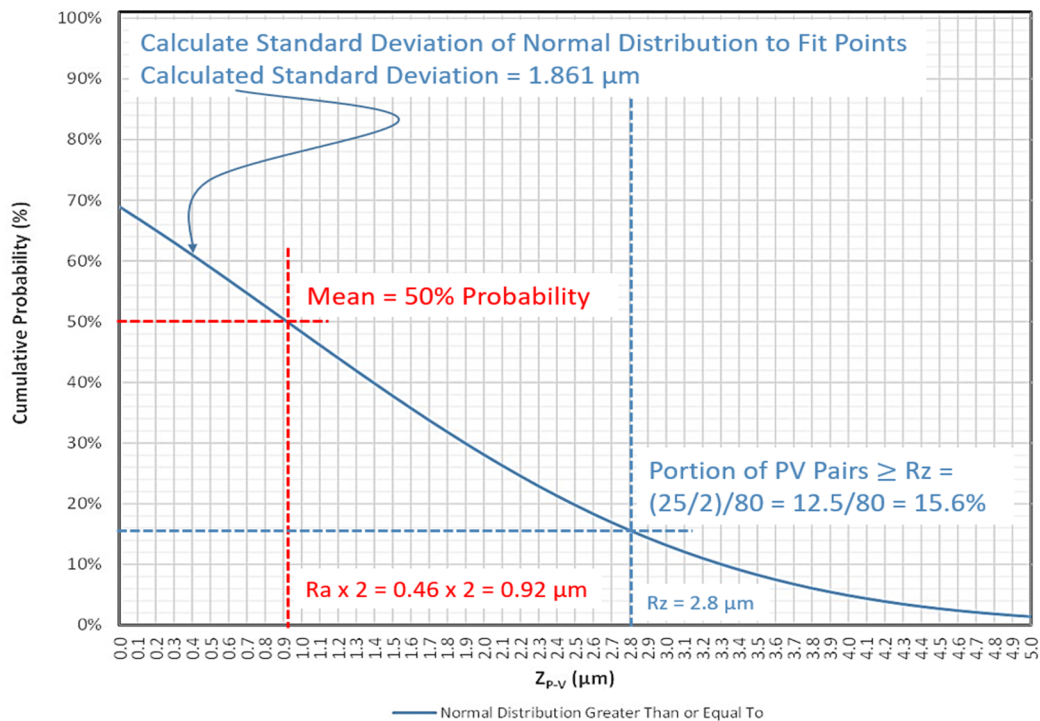
given the Rz and Ra values of a given foil surface. This could be accomplished simply by doubling the Ra values (as Ra values are the average of the *absolute values* of all of the height values (positive or negative) measured as illustrated below for the digitized Griesi surface profile). SOLUS-1015, 54. As shown below, doubling Ra about the centerline effectively “unfolds” the absolute value data about the centerline, establishing an average Peak-Valley (P-V) dimension. This is accomplished simply by multiplying Ra x 2 as illustrated below. This value establishes the average peak-to-valley dimension of the profilometer scan as shown below, with half of the peak-valley pairs being larger than Ra x 2 and half being smaller than Ra x 2.



54. A POSITA would then fit a normal (Gaussian) distribution through the 2 x Ra value of interest (as 50% cumulative probability), as well as through the point on the cumulative probability distribution indicated by Rz (e.g., the portion of the peaks that correspond to Rpc (calculated above) divided by 12.5 (which is

25 Rz Peak-Valley pairs per Evaluation length (l_n) divided by 2, at the x-axis value indicated by the associated Rz value) in order to calculate the standard deviation of the fitted normal (Gaussian) distribution, using Excel or Minitab, or the like, as understood by a POSITA, as shown below for the S side of Shinozaki Work. Ex. 6.





55. A POSITA would have understood to use the calculated standard deviation of the normal (Gaussian) distribution above to then calculate the portion of the total number of P-V pairs per 4 mm Evaluation length (l_n) that would have exceeded 1.0 μm (e.g., the distance from -0.5 μm to 0.5 μm). In Excel, the equation would be:

$$=1-\text{NORM.DIST}(1, D12, E12, \text{TRUE})$$

where:

$$D12 = 2 \times R_a$$

E12 = The Standard Deviation Calculated Above

TRUE returns the cumulative probability

which returns the value of 0.483 in the case of the S side of Working Example 6 of Shinozaki, meaning that 48.3% of the total number of P-V pairs would exceed 1 μm in Peak-to-Valley dimension, or the space between the upper criterion line (+0.5 μm) and the lower criterion line (-0.5 μm) as the distribution is symmetric about the centerline. Thus, $0.483 \times 80 = 38.6$, which rounds to 39 peaks for the S side of Working Example 6 meeting the Rpc criterion of claim 1 of the '090 Patent. This is in agreement with the ~40 peaks calculated using a different approach above, thus verifying both methods.

56. For example, the S side of Working Example 6 of Shinozaki is characterized by $R_a = 0.46 \mu\text{m}$, $R_z = 2.8 \mu\text{m}$, and S_m of 50 μm . Thus, as described above, the total number of Peak-Valley pairs is $(l_n/S_m) = (4 \text{ mm} \times 1000 \mu\text{m}/\text{mm})/50.00 \mu\text{m} = 4,000 \mu\text{m}/50.00 \mu\text{m} = 80$. And 15.6% of those 80 Peak-Valley pairs (e.g., $(25/2)/80 = 15.6\%$) occur at or above a Peak-Valley height dimension of 2.8 μm (e.g., the R_z value of 2.8 μm), as $25/2 = 12.5$ P-V pairs occur at height values $\geq 2.8 \mu\text{m}$. Fitting a normal distribution having mean (e.g., 50% cumulative probability) value of 0.92 μm (e.g., $2 \times R_a = 2 \times 0.46 \mu\text{m} = 0.92 \mu\text{m}$), and 15.6% cumulative probability greater than the R_z value of 2.8 μm , yields a standard deviation for said normal (Gaussian) distribution of 1.861 μm . Using the standard deviation of 1.861 μm to calculate the portion of the distribution that is

$\geq 1.0 \mu\text{m}$ yields a portion of 48.3% (or 0.483). Multiplying this portion by the total number of Peak-Valley pairs (e.g., 80) yields $0.483 \times 80 = 38.6$ or 39 Peak-Valley pairs having a height difference of $\geq 1.0 \mu\text{m}$ (or $\pm 0.5 \mu\text{m}$, since the distribution is centered about the centerline).

57. By applying the above normal (Gaussian) distribution calculations to the examples disclosed in Shinozaki, it is evident that at least 4 examples (e.g., both the S and the M sides of Working Examples 5 and 6, and of Comparative Examples 7 and 8) are within the '090 Patent's claimed range of R_{pc} from 10 to 100 as tabulated below. As shown, the calculated R_{pc} values of Working Example 6 correspond to 39 and 71 for the S surface and M surface, respectively. Here, R_{pc} of 39 for the S side of Working Example 6 agrees well with the calculation of 40 above, validating both calculation methods. Additionally, the calculated R_{pc} values for Working Example 5 corresponds to 64 and 15 for the S surface and the M surface respectively, and the calculated R_{pc} values of Working Examples 1 through 3 for the M surface correspond to 87, 96, and 78 respectively. Indeed, 14 of the 28 surfaces disclosed in Table 3 of Shinozaki have calculated R_{pc} within the claimed range.

		Calculated R _{pc} after roughening	
		S surface	M surface
Work. Ex. 1	A1	107	87
Work. Ex. 2	A1	141	96
Work. Ex. 3	A1	121	78
Work. Ex. 4	A1	180	110
Comp. Ex. 1	A1	142	189
Comp. Ex. 2	A1	104	40
Work. Ex. 5	A2	64	15
Work. Ex. 6	A3	39	71
Comp. Ex. 3	A3	92	177
Comp. Ex. 4	B1	133	137
Comp. Ex. 5	B1	100	109
Comp. Ex. 6	B1	213	110
Comp. Ex. 7	B2	93	74
Comp. Ex. 8	B3	43	28

58. Accordingly, Shinozaki's R_{pc} values (that satisfy the teachings of Shinozaki) fall within the claimed range of R_{pc} of "10 to 100."

59. Regarding limitation [1d], S_m, which is correlated with and can be used to calculate or derive R_{pc}, is an average value of S_m values measured at multiple randomly selected points, thus rendering this limitation obvious. *See* SOLUS-1017, 16-18. A POSITA would find it obvious and reasonable to make

such random measurements over at least three randomly selected points or locations, in order to reduce sampling bias. Further, the surface roughness manual generally explains that surface roughness parameters are measured according to randomly sampled places. See SOLUS-1017, 3 (explaining that surface roughness parameters correspond to “the parameters expressing the surface roughness at each part sampled randomly from the surface”). Indeed, the Standard (JIS-B-0601-1994) discloses the use of random sampling throughout. See, e.g., *id.* 3, 10, 12, 15, 18, 21, 24, 27.

60. Moreover, because [1] Shinozaki teaches having both surfaces (shiny surface and matte surface) of the electrolytic copper foil exhibiting similar surface characteristics and [2] it was conventional to process both sides to exhibit similar surface roughness characteristics, a POSITA would have applied similar *R_{pc}* values to both sides of the electrolytic copper foil. SOLUS-1004, [0122], [0073], [0074]; SOLUS-1008, [0005], [0008]; SOLUS-1009, 1:12-18, 12-22-26.

61. For the reasons set forth above, Shinozaki renders obvious [1c]-[1e].

4. Additionally, a POSITA [1] would have recognized that *R_{pc}* is a recognized, result-effective variable, and [2] would've been motivated to further optimize *R_{pc}* or otherwise confirm whether *R_{pc}* in Shinozaki aligns with Shinozaki's teachings of other surface roughness parameter values

62. For the following reasons, *R_{pc}* is a recognized, result-effective variable known to be correlated with [1] enhancing surface roughness

characteristics and [2] providing void-reduced and uniform copper deposits, which are related to enhancing adhesion properties of the electrolytic copper foil.

SOLUS-1004, [0073], [0074].

63. First, it was well-known that “[b]y controlling spacing parameters [e.g., roughness parameters such as R_{pc} , R_{sm} , S_m] it is possible to obtain better bounding [e.g., bonding] of finishes, more uniform finish of plating.” SOLUS-1016, 7. For example, prior art emphasizes that “[o]ne of the spacing parameter is the *peak spacing*, which can be an important factor in the performance of *friction surfaces*.” *Id.* Here, spacing parameters are important in optimizing the performance of surface where friction is important, enhancing attributes like mechanical grip between the current collector and the active material of secondary batteries. For example, the performance of frictional contact or mechanical grip (e.g. adhesion) between the active material and the current collector is directly linked to the adhesion between them, which can improve resistance to degradation of the copper foil surface on the current collector during repeated battery charge/discharge cycles, etc.

64. Second, although R_{pc} is categorized as a spacing parameter, its determination based on upper and lower criteria lines establishes a correlation with height (e.g., amplitude) parameters such as R_a (the average height of the surface roughness from the mean line). Particularly, as stated in the claim language [1e],

peaks are counted as “effective peaks” only if they satisfy height threshold requirements of “upper criteria line of $0.5\ \mu\text{m}$ ” and “lower criteria line of $-0.5\ \mu\text{m}$.” Therefore, if R_{pc}’s upper/lower criteria lines are set to values such as $\pm 0.5\ \mu\text{m}$ that are similar to average height R_a value(s) taught in Shinozaki (e.g., R_a of $0.25\text{--}0.7\ \mu\text{m}$), then R_{pc} becomes correlated with R_a, as they both express height characteristics. In other words, R_a and R_{pc} are correlated in certain scenarios. One scenario corresponds to the following: when average height R_a of surface roughness is near $0.5\ \mu\text{m}$, and R_{pc} upper/lower criteria lines are set to $\pm 0.5\ \mu\text{m}$, approximately half of the peaks will rise above and fall below the upper/lower criteria lines, thereby directly contributing to number of effective peaks of R_{pc}. This indicates that:

- [1] By controlling R_{pc} (as a *result-effective variable*) based on its height characteristics (e.g., upper/lower criteria lines), a POSITA can target and obtain certain surface profile characteristics, such as consistency or distribution of peaks that meet the threshold height. This consistency or uniformity of peaks is related to enhancing the surface properties of the electrolytic copper foil, thereby improving the adhesion between the current collector and the active material of the secondary battery; and
- [2] The objective of controlling R_{pc} can also be correlated with the objective of controlling R_a (average surface roughness), one goal of which is to

enhance the surface properties of the electrolytic copper foil so as to improve adhesion (and consistency of adhesion) between the foil and the active material of the secondary battery. *See* SOLUS-1004, [0044], [0045], [0073], [0074]; *see also* SOLUS-1032 (“Since the copper layer 30 having a substantially uniform surface is formed, the adhesion strength between the copper alloy foil 10 and the active material layer 40 can be improved by the anchor effect”); SOLUS-1033 (“roughened particles having non-uniformness and high degree of roughness weaken the anchoring effect, and high adhesion between the negative electrode current collector and the negative electrode active material can not be obtained”).

65. Third, it was demonstrated that Rpc is associated with providing void-reduced, smoother, and more uniform copper deposits, which are the features that are related to enhancing adhesion properties of the copper foil. For example, in prior art (Fabian), in studying the effects of organic additives on the production of void-reduced, smoother, and more uniform copper deposits, PPC (which is a proxy for Rpc per at least DIN EN ISO 4287 as discussed below) was used as one of main parameters to evaluate these effects. SOLUS-1005, Abstract (“The effect of . . . [organic additives such as] Guarfloc66 (Guar) and activated polyacrylamide (APAM) on the topography (surface roughness) of electrodeposited copper was studied,” “*The effect of* [organic additives such as] Guar and APAM on surface

roughness and *number of Peaks-per-Centimeter*⁵ [corresponding to *Ppc* or *Rpc*] *was assessed* . . . Observed effects on surface roughness indicate that a *more uniform surface and lower roughness/smoothier copper deposits* were obtained using the additive APAM rather than Guar . . . The cross sections of copper deposits from these tests showed that APAM exhibits a *slightly columnar* copper deposit and Guar produced a *porous* copper deposit”), 8 (“It is concluded from these results that *APAM* significantly reduced surface roughness and *increased the number of PPC [Rpc]*. In contrast, *Guar* increased the surface roughness and *decreased the number of PPC similar to the copper deposit produced without additives.*”), 8 (“The model for the PPC [Rpc] is presented in Eq. (4) . . . [where Ep.(4) corresponds to:] Number of Peaks [Rpc] per Centimetre = $85.2 + 0.313 * A + 8.81 * B$ (4),” where A is Guar concentration and B is APAM concentration), 11, FIGS. 8, 11. Further, prior art (Fabian) simultaneously discloses [1] copper deposits [e.g., foils as would be understood by a POSITA, especially with regard to deposits fabricated using the rotating cylindrical electrode (RCE)] that can be used for printed circuit board (PCB) and microelectronics, which can be compatible

⁵ DIN EN ISO 4287 measurement standard known to share the same definition of *Rpc* describes that the term “*Rpc*” is also interchangeably used with “*PPc*” or “*WPc*.” SOLUS-1019, 20, 21.

with use in secondary batteries and [2] Rpc values of the copper foil that fall within the claimed Rpc range, describing that such Rpc values are useful values *for enhancing uniformity or void reduction of copper foil surface*, which also aligns with a design objective in Shinozaki. SOLUS-1005, 2, Tables 1, 6; SOLUS-1004, [0073]; *see also* SOLUS-1011, [1], [7], [14]-[15], [45]-[46], claims 9, 10 (disclosing that a copper foil with improved adhesion and reliability for use in PCB applications can also be used in batteries); SOLUS-1007, [0107]; SOLUS-1008, [0001], [0005], [0012], [0066].

66. Therefore, it is my opinion that a POSITA [1] would've recognized that Rpc is a result-effective variable that affects adhesion properties of electrolytic copper foil and [2] would've been motivated to further optimize Rpc or otherwise confirm whether Rpc in Shinozaki's copper foil aligns with Shinozaki's teachings of other surface roughness parameter values. The rationale is summarized as follows:

- [i] Rpc is a known spacing parameter that can be controlled "to obtain better bounding of finishes, more uniform finish of plating";
- [ii] it was known that peak spacing (that is correlated to Rpc, as described above) is an "important factor in the performance of friction surfaces," which is relevant to enhancing mechanical grip (adhesion) between the current collector and the active material of secondary batteries;

[iii] it was known that, by controlling R_{pc} based on R_{pc}'s height characteristics (e.g., upper/lower criteria lines), a POSITA would target to obtain certain surface profile characteristics, such as consistency or distribution of peaks that meet the threshold height requirement and/or other height parameters (e.g., R_a);

[iv] in many instances, the objective of controlling R_{pc} can also be correlated with the objective of controlling R_a (average surface roughness);

[v] it was demonstrated that R_{pc} is associated with providing void-reduced, smoother, and more uniform copper deposits; and

[vi] R_{pc} values⁶, such as 33.1⁷ and 33.3⁸ in prior art (Fabian) have been shown to be effective toward enhancing uniformity or void reduction of copper foil surface, which also aligns with the design objectives of

⁶ According to the DIN EN ISO 4287 measurement standard, it is recommended to use $\pm 0.5 \mu\text{m}$ as the upper/lower criteria line height threshold. Unless otherwise specified by Fabian, Fabian should have followed this recommendation and use the $\pm 0.5 \mu\text{m}$ criteria lines. SOLUS-1019, 20-21.

⁷ Converted from 82.75 peaks / 1 cm to 33.1 peaks / 4 mm. SOLUS-1005, 8, Table 6.

⁸ Converted from 83.38 peaks / 1 cm to 33.3 peaks / 4 mm. *Id.*

Shinozaki (e.g., providing void-reduced surfaces to enhance adhesion properties). *See* SOLUS-1016, 7; SOLUS-1005, Abstract, 8, 11, FIGS. 8, 11; SOLUS-1004, [0073].

67. Further, it is my opinion that a POSITA would have expected success in optimizing R_{pc} .

First, the optimization of R_{pc} would have involved a mere routine optimization of electrodeposition conditions, such as varying concentrations of additives (e.g., organic additives), electrolysis solution chemistry, which includes copper sulfate and sulfuric acid, treatment time, and/or current density. For instance, as demonstrated in Fabian, simple variation of concentration of organic additives, such as Guar or APAM, affects R_{pc} values. SOLUS-1005, Abstract, 8. Further, for instance, it was demonstrated in prior art (Dobashi) that variation of electrolysis solution and/or current densities are factors that contribute to the control of S_m or R_{sm} values, which are directly correlated with R_{pc} values. SOLUS-1007, Table 4 (demonstrating comparison of R_{sm} values between Examples 1-7 and Comparative Example), [0020]-[0022] (disclosing varying of current densities in electrolysis), [0023]-[0028] (disclosing specific compositions and concentrations of electrolytic solutions), [0097] (disclosing experimental conditions for the Comparative Example).

68. Second, as described in the preceding paragraph, prior art (Fabian) along with prior known knowledge, suggests the experimentation needed to achieve the values (e.g., R_{pc} of 33.1 and 33.3 of Fabian) that fall within the claimed range (R_{pc} of 10-100), thereby contributing to the reasonable expectation of success and the rationale for obviousness.

69. Third, as described above, because R_{pc}'s recommended upper and lower criteria thresholds are 0.5 μm and -0.5 μm respectively, which fall within the Ra range (0.25-0.7 μm) taught by Shinozaki, the objective of controlling R_{pc} can also be correlated with the objective of controlling Ra (average surface roughness). For instance, as described above, one objective of controlling Ra in Shinozaki is to enhance adhesion properties of copper foil surface. Similarly, controlling R_{pc} can achieve the same goal by ensuring consistency or uniformity of peaks that meet the threshold height (e.g., upper and lower criteria lines such as $\pm 0.5 \mu\text{m}$).

Accordingly, a POSITA would have known to control R_{pc}, either alone or in addition to Ra, in order to enhance surface uniformity near the threshold height of 0.5 μm and thus reduce voids for example, thereby improving adhesion properties and confirming consistency or distribution of peaks that meet the teachings of Ra in Shinozaki.

70. Fourth, as described above with respect to motivation to optimize R_{pc}, advantages of optimizing R_{pc} were well-demonstrated in prior art. For

instance, [1] it was known to use Rpc “to obtain better bounding of finishes, more uniform finish of plating,” [2] it was known that peak spacing (that is correlated to Rpc, as described above) is an “important factor in the performance of friction surfaces,” which is relevant to enhancing mechanical grip (adhesion) between the current collector and the active material of secondary batteries, and [3] it was known to use Rpc to enhance uniformity or void reduction of copper foil surface. SOLUS-1016, 7; SOLUS-1005, Abstract, 8, 11, FIGS. 8, 11; SOLUS-1004, [0073].

71. Therefore, it is my opinion that a POSITA [1] would have known that Rpc is a recognized, result-effective variable, and [2] would have been motivated to further optimize Rpc in addition to Shinozaki’s teachings of other surface roughness parameter value(s).

5. Additionally, it was demonstrated in prior art (Fabian) that [1] Rpc within the claimed range was effective toward surface adhesion characteristics (e.g., uniform surface) and [2] Fabian’s electrolytic copper deposit [foil] can be used toward forming a current collector of secondary batteries

72. First, as noted above, Fabian discloses electrodeposited copper (as would be understood by a POSITA to be a foil, especially within the context of the rotating cylinder electrode (RCE)) which has two surfaces, and that can be used for printed circuit boards (PCB) and microelectronics, is also understood by a POSITA to be compatible with use in secondary batteries. Such use compatibility of

electrodeposited copper foil between the PCB and the secondary batteries were well-known. SOLUS-1011, [1], [7], [14]-[15], [45]-[46], claims 9, 10 (disclosing that a copper foil with improved adhesion and reliability for use in PCB applications can also be used in batteries); SOLUS-1007, [0107]; SOLUS-1008, [0001], [0005], [0012], [0066].

73. Second, Fabian discloses R_{pc} values that fall within the claimed range. As described above, Fabian discloses R_{pc} values such as 33.1 and 33.3, which fall within the claimed range, and at the same time, these values in Fabian were shown to be effective toward enhancing uniformity or void reduction of copper foil surfaces. Additionally, Fabian discloses R_{pc} values of 26.0 and 35.0, which were not treated with specific organic additive APAM, but still can be used as electrolytic copper foils for PCB and secondary batteries. SOLUS-1005, 8, Table 6. For example, 26.0 peaks / 4 mm was converted from 65.13 peaks / 1 cm and 35.0 peaks / 4 mm was converted from 87.63 peaks / 1 cm in Table 6 of Fabian.

74. Third, as described above, because [1] Shinozaki teaches having both surfaces (shiny surface and matte surface) of the electrolytic copper foil exhibiting similar surface characteristics and [2] it was conventional to process both sides to exhibit similar surface roughness characteristics, a POSITA would have targeted similar R_{pc} values to both sides of the electrolytic copper foil in Fabian. SOLUS-

1004, [0073]-[0074], [0122]; SOLUS-1008, [0005], [0008]; SOLUS-1009, 4:23-28, 4:57-60, 6:36-37.

75. At least for the reasons described above, it is my opinion that Fabian in view of conventional knowledge alternatively and/or additionally renders obvious the limitation of overall claim 1.

(ii) Claim 2

[2] The electrolytic copper foil according to claim 1, wherein a difference in peak count roughness R_{pc} between the first and second surfaces is 60 or less.

76. As noted above and depicted in the Table below, Shinozaki discloses R_{pc} of 39 and 71 (e.g., for S and M surfaces of Shinozaki's Working Example 6) and R_{pc} of 64 and 15 (e.g., for S and M surfaces of Working Example 5). Here, the difference in R_{pc} of S and M surfaces of Shinozaki's Working Example 6 equates to 32 (e.g., $71 - 39 = 32$), and the difference in R_{pc} of S and M surfaces of Shinozaki's Working Example 6 equates to 49 (e.g., $64 - 15 = 49$), thereby rendering obvious [2].

		Calculated R _{pc} after roughening	
		S surface	M surface
Work. Ex. 1	A1	107	87
Work. Ex. 2	A1	141	96
Work. Ex. 3	A1	121	78
Work. Ex. 4	A1	180	110
Comp. Ex. 1	A1	142	189
Comp. Ex. 2	A1	104	40
Work. Ex. 5	A2	64	15
Work. Ex. 6	A3	39	71
Comp. Ex. 3	A3	92	177
Comp. Ex. 4	B1	133	137
Comp. Ex. 5	B1	100	109
Comp. Ex. 6	B1	213	110
Comp. Ex. 7	B2	93	74
Comp. Ex. 8	B3	43	28

77. Further, as described above, because [1] Shinozaki teaches having both surfaces (shiny (S) surface and matte (M) surface) of the electrolytic copper foil exhibiting similar surface characteristics and [2] it was conventional to process both sides to exhibit similar surface roughness characteristics, a POSITA would have endeavored to achieve similar R_{pc} values to both sides of the electrolytic

copper foil in Shinozaki. *See* SOLUS-1004, [0004], [0073], [0074], [0122]; SOLUS-1008, [0005], [0008]; SOLUS-1009, 1:12-18.

78. Because it is preferable that shiny and matte surfaces exhibit similar surface profiles, a difference in peak count roughness R_{pc} between the first and second surfaces would be minimized and would easily be 60 or less (e.g., similar or equal surfaces would yield a number close to 0, which is less than 60).

Additionally, calculations of Shinozaki Table 3 indicate that at least 10 of the 14 examples in Table 3 of Shinozaki have a difference in peak count of 60 or less.

Accordingly, Shinozaki renders obvious this claim limitation.

(iii) Claim 3

[3] The electrolytic copper foil according to claim 1, wherein each of the first and second surfaces has a ten-point mean roughness R_{zJIS} of 2 μm or less.

79. Shinozaki teaches the electrolytic copper foil surface having a 10-point mean roughness R_z (or R_{zJIS}) of 1.0 – 5 μm and both surfaces exhibiting similar roughness characteristics. SOLUS-1004, Abstract, [0031], [0032], [0073], [0074].

80. Further, as explained in Fabian, “[a] surface profile can have the same surface roughness with a different number of PPC [R_{pc}].” SOLUS-1005, 7, 8. In other words, a surface profile can have the same R_{pc} value while having a different surface roughness R_z value, unless the R_z value is significantly changed (e.g., to

less than 1 μm) so as to affect the number of peaks that cross the upper and lower criteria lines in determining R_{pc} .

81. Accordingly, Shinozaki's teaching of R_z value in the range of 1.0-5 μm overlaps with claimed range of "2 μm or less" and thus renders it obvious. Further, the '090 Patent provides no indication of criticality or unexpected results associated with the claimed range of R_z .

(iv) Claim 4

[4] The electrolytic copper foil according to claim 1, wherein the electrolytic copper foil has a thickness of 3 to 20 μm and tensile strength of 30 to 60 kgf/mm^2

82. First, in regard to the "thickness of 3 to 20 μm " feature, Shinozaki describes that "[i]n the present invention, the [current] collector is preferably one having a thin thickness . . . [in which the current collector] is preferably an electrolytic copper foil" and that [t]he thickness of the collector is preferably 8 μm when it is thin, while it is about 20 μm when it is thick." SOLUS-1004, [0072], [0073]. "This is because, the strength of the foil cannot be maintained when it is less than 8 μm , therefore breakage occurs at the time of expansion/contraction of the active material. Further, when it exceeds 20 μm , the battery characteristics can be satisfied, but the battery itself becomes large and heavy, therefore, preferably, the thickness is up to about 20 μm ." SOLUS-1004, [0073]. Moreover, Shinozaki Table 2 lists the thickness of untreated copper foil, such as "10 μm ."

83. Further, roughening treatment of the copper foil surface would likely have had minimal effect on the thickness of the copper foil itself, thus complying with the teachings of Shinozaki. For example, the roughening treatment typically involves the formation of fine surface structures, such as nodules, which primarily increase surface area for better adhesion rather than significantly contributing to the overall thickness of the foil. Shinozaki, in discussing roughening treatments, does not suggest any substantial addition to the foil's thickness. Instead, the roughening layer typically adds a negligible amount of material. In the case of Working Example 5 for example, the added thickness is likely less than 1 μm , which would not meaningfully alter the copper foil's overall thickness, thereby ensuring that the copper foil still falls within the claimed thickness range of 3 to 20 μm .

84. Second, in regard to the “tensile strength of 30 to 60 kgf/mm^2 ” feature, Shinozaki describes that “the copper foil is preferably electrolytic copper foil which has . . . a tensile strength of 300 N/mm^2 *or more* at ordinary temperature.” SOLUS-1004, [0050]. Accordingly, $300\text{N/mm}^2 \times (0.10197 \text{ kgf/mm}^2 / \text{N/mm}^2) = 30.591\text{kgf/mm}^2$. Moreover, Shinozaki Table 2 lists the tensile strength of untreated copper foil, ranging from **31.6 kgf/mm^2** to **40.8 kgf/mm^2** (converted from a range of 310-400 N/mm^2).

85. Further, roughening treatment of the copper foil surface would likely have had insignificant effect on the mechanical properties (e.g., tensile strength of the copper foil), thus complying with the teachings of Shinozaki. For instance, Shinozaki focuses on producing copper foils for a current collector where “breakage of the [current] collector does not occur” and of copper foils that have high “elongation at failure” — meaning they stretch (deform plastically) significantly before breaking (i.e., ductile failure as opposed to brittle failure) SOLUS-1004, [0029], [0040], [0041], [0050], [0051]. Thus, these ductile failure materials that stretch (plastically deform) prior to breaking would experience insignificant effect in tensile strength from surface roughness treatment, as their associated failure origin would be internal (i.e., within the bulk of the foil as opposed to at a surface of the foil). Accordingly, Shinozaki’s roughening treatments wouldn’t have significant effect on foil tensile strength, especially since it was an objective of Shinozaki to achieve 300 N/mm² (30.59 Kgf/mm²) *or more* ordinary temperature tensile strength. *Id.*, [0050]-[0051].

(v) Claim 7

[7pre] An electrode for a secondary battery, the electrode comprising:

86. Shinozaki discloses an electrolytic copper foil for negative electrode current collectors of lithium-ion secondary batteries. SOLUS-1004, Abstract,

[0041] (“the lithium ion secondary battery of the present invention uses the above electrolytic copper foil for the above negative electrode of the battery”).

[7a] a current collector comprising the electrolytic copper foil according to claim 1; and

87. Shinozaki describes that “[t]he electrolytic copper foil for lithium ion secondary battery is used as the [current] collector” and “[i]n the present invention, the [current] collector is preferably one having a thin thickness . . . [in which the current collector] is preferably an electrolytic copper foil.” SOLUS-1004, [0002], [0038], [0072]; *see* discussion *supra* claim 1. Further, the terms “current collector” and “collector” are used synonymously throughout Shinozaki as would be understood by a POSITA. *See* SOLUS-1004, [0002], [0003], [0004], [0010], [0028], [0051].

[7b] an active material layer disposed on the current collector;

88. Shinozaki describes the active material layer that is disposed on the current collector. SOLUS-1004, [0040] (“there can be provided an electrode for lithium ion secondary battery and a lithium ion secondary battery . . . having a high adhesion between the active material and the collector”), [0029], [0038] (“The electrolytic copper foil for lithium ion secondary battery is used as the collector, and the active material which is deposited on its surface is comprised of primary

particles of silicon, germanium, or tin or an alloyed compound of the same or of secondary particles which are obtained by processing the primary particles”).

[7c] wherein the active material layer comprises at least one active material selected from the group consisting of: carbon; a metal (Me) of Si, Ge, Sn, Li, Zn, Mg, Cd, Ce, Ni or Fe; an alloy containing the metal; an oxide of the metal (MeOx); and a chemical compound of the metal and carbon.

89. As described above, Shinozaki describes that the active material is “comprised of primary particles of silicon, germanium, or tin.” SOLUS-1004, [0038].

(vi) Claim 8

[8] The electrode according to claim 7, wherein the active material layer comprises Si.

90. As described above, Shinozaki describes that the active material is “comprised of primary particles of silicon.” SOLUS-1004, [0038].

(vii) Claim 10

[10pre] A secondary battery comprising:

91. *See discussion supra* section [1pre].

[10a] a cathode; an anode; an electrolyte for providing an environment enabling lithium ions to move between the cathode and the anode; and a separator for electrically insulating the cathode from the anode,

92. Shinozaki describes that “[t]he lithium ion secondary battery of the present invention is provided with *a negative electrode [anode]* formed by an

electrode for lithium ion secondary battery of the present invention described above, ***a positive electrode [cathode]*** using a substance occluding/releasing lithium for the active material, and a nonaqueous ***electrolyte***.” SOLUS-1004, [0079].

93. Moreover, it was conventional that [1] the electrolyte is for providing an environment enabling lithium ions to move between the cathode and the anode and [2] the secondary battery would have a separator for electrically insulating the cathode from the anode. SOLUS-1012, [0006] (“A lithium secondary battery generally includes a cathode and an anode, which are arranged with a separator being interposed between them, and an electrolyte”).

[10b] wherein the anode comprises: a current collector comprising the electrolytic copper foil according to claim 1; and

94. Shinozaki describes that “[t]he lithium ion secondary battery of the present invention is provided with a negative electrode formed by an electrode for lithium ion secondary battery of the present invention” and teaches the electrolytic copper foil for use in current collector of the negative electrode, having the surface roughness characteristics as described above with respect to claim 1. SOLUS-1004, [0079], [0075]; *See discussion supra* claim 1, 7.

[10c] an active material layer disposed on the current collector.

95. As described above, Shinozaki describes the active material layer disposed on the current collector. SOLUS-1004, [0029], [0038], [0040]; *See* discussion *supra* section [7b].

B. [GROUND 1B] – CLAIMS 5, 6, 9, and 11 ARE OBVIOUS OVER SHINOZAKI AND TOSHIO (OR KIM)

Overview of Toshio

96. Toshio describes a current collector for use in secondary batteries. SOLUS-1014, Abstract (“This is a negative electrode for a *secondary battery* in which a Si-based negative electrode active material film of a predetermined thickness containing hydrogenated silicone with a predetermined hydrogen concentration is formed on a *current collector substrate having a predetermined surface*”), [0051] (“copper foil is used as the base material of the current collector (current collector base material) used in the negative electrode for the secondary battery of the first embodiment”).

97. Toshio also describes an electrolytic copper foil having surface(s) that undergo a roughening process. *Id.*, [0054] (“When forming an active material on both sides of any copper foil, roughening treatment on at least one side is required”). Relatedly, Toshio focuses on improving cycle characteristics of secondary battery by at least [1] using a predetermined silicon-based active

material and [2] enhancing adhesion between the current collector and the active material. *See id.*, [0010]; [0011].

98. Toshio further describes that using a protective layer such as a chromate layer, a benzotriazole layer, or a silane coupling treatment layer on the copper foil provides many advantages including heat resistance, rust prevention, and adhesion enhancement. *See id.*, [0074], [0092]-[0093], [0111], [0131], [0141], [0175], [0192], [0199], [0216].

Overview of Kim

99. Kim describes a current collector for use in secondary batteries. SOLUS-1012, Abstract, [0003] (“The present invention relates to a copper foil used as a current collector of a lithium secondary battery, and more particularly to a copper foil for a current collector of a lithium secondary battery”).

100. Kim focuses on [1] preventing wrinkles on surfaces of copper foil for a current collector [2] enhancing adhesion between the current collector and the active material. *Id.*, Title, Abstract, [0010] (“it is an object of the present invention to provide a copper foil for a current collector of a lithium secondary battery with a crystal structure capable of decreasing the generation of wrinkles at a surface of the copper foil”), [0026] (“If the texture coefficients are not within the above ranges, many wrinkles are created in a width direction of the copper foil, and accordingly

the adhesion of active material to the surface of the copper foil may be deteriorated when the active material is coated”).

101. Kim further describes that using a protective layer including a chromate layer provides advantages including corrosion prevention. *See id.*, [0007], [0024], [0025], [0028].

Reasons for combining Shinozaki with Toshio or Kim

102. It is my opinion that a POSITA would have been motivated to apply Toshio’s or Kim’s teachings regarding use of a protective layer to Shinozaki’s electrolytic copper foil for a current collector and would have expected success, as described below.

103. First, as described above, both Shinozaki and Toshio or Kim describe the use of electrolytic copper foil for a current collector for a secondary battery.

104. Second, as described above, both Shinozaki and Toshio or Kim describe the use of electrolytic copper foil with roughened surfaces. For instance, [1] Shinozaki describes “surface-roughened layer of copper or copper alloy particles” being “formed on both surfaces of an untreated copper foil by roughening treatment by means of electrolysis,” [2] Toshio describes that “[w]hen forming an active material on both sides of any copper foil, roughening treatment on at least one side is required” and [3] Kim describes that “[a]s the plating

conditions to obtain the crystalline structure, copper is electrodeposited onto a drum surface of a foil making machine . . . to make an original foil, and a nodule is formed thereat as necessary.” SOLUS-1004, Abstract; SOLUS-1014, [0054]; SOLUS-1012, [0025].

105. Third, as described above, both Shinozaki and Toshio or Kim share the same goal of enhancing adhesion between the current collector and the active material.

106. Fourth, as described above, Toshio and Kim describe that using a protective layer such as a chromate layer, a benzotriazole layer, or a silane coupling treatment layer on the copper foil provides many advantages including heat resistance, rust prevention, corrosion prevention, and adhesion enhancement.

107. Fifth, it is my opinion that applying protective layer(s) such as a chromate layer, a benzotriazole layer, or a silane coupling treatment layer on the copper foil was conventional.

108. At least for the reasons set forth above, it is my opinion that a POSITA would have been motivated to apply Toshio’s or Kim’s teachings regarding use of a protective layer to Shinozaki’s electrolytic copper foil for a current collector and would have expected success in doing so.

(i) Claim 5

[5pre] A current collector for a secondary battery, the current collector comprising:

109. Shinozaki describes that “[t]he electrolytic copper foil for lithium ion secondary battery is used as the [current] collector” and that the current collector includes an electrolytic copper foil. SOLUS-1004, [0002], [0038], [0040], [0072].

[5a] the electrolytic copper foil according to claim 1; and

110. As described above with respect to discussion of claim 1, Shinozaki describes that “[t]he electrolytic copper foil for lithium ion secondary battery is used as the [current] collector” and focuses on describing surface characteristics of the electrolytic copper foil. SOLUS-1004, [0002], [0038], [0040]; *see* discussion *supra* claim 1.

[5b] a protective layer disposed on the electrolytic copper foil,

[5c] wherein the protective layer comprises at least one of chromate, benzotriazole and a silane compound.

111. Shinozaki and Toshio (or Kim) combination renders obvious [5b]-[5c].

112. Upon my review, the '090 Patent describes that the protective layer can be formed when “the electrolytic copper foil” is “subjected to anti-corrosion treatment using chromate, benzotriazole, and/or a silane compound.” *See, e.g.* SOLUS-1001, 5:65-6:11, 6:65-7:3.

113. Similarly, in the Shinozaki and Toshio (or Kim) combination, Toshio or Kim teaches protective layer(s) applied to the electrolytic copper foil surface. For instance, as described above, Toshio teaches using a protective layer such as *a chromate layer, a benzotriazole layer, or a silane coupling treatment layer* on the copper foil and describes advantages including heat resistance, rust prevention, and adhesion enhancement. *See* SOLUS-1014, [0074], [0092]-[0093], [0111], [0131], [0141], [0175], [0192], [0199], [0216]. Further for instance, as described above, Kim teaches applying *a protective layer* including a *chromate layer* (e.g., “surface-chromated”) to the electrolytic copper foil surface and describes corresponding advantages including “the prevention of corrosion.” SOLUS-1012, [0007], [0024], [0025], [0028].

(ii) Claim 6

[6] The current collector according to claim 5, wherein the protective layer is formed on the first and second surfaces of the electrolytic copper foil.

114. Shinozaki and Toshio (or Kim) combination renders obvious this limitation.

115. Particularly, as described in Toshio and as conventionally understood by a POSITA, [1] active material is typically formed on both surfaces of the current collector substrate and [2] protective layer(s), such as anti-rust layer(s) or corrosion-proof layer(s) is/are applied in between the copper foil surfaces of the current collector and the active material layer. SOLUS-1014, claim 6 (“According

to any one of Claims 1, 2, and 4, a negative electrode for a secondary battery, characterized in that one or more silicone layers containing phosphorus or boron are ***formed between*** the current collector substrate and the silicone-based active material film”), claim 9 (“According to any one of Claims 1, 2, and 4, a negative electrode for a secondary battery characterized in that a heat-resistant layer or a heat-resistant barrier film is ***formed on the surface of the current collector substrate*** on which the active material film is formed”), claim 10 (“According to Claim 9, a negative electrode for a secondary battery, characterized in that a rust-prevention layer and/or a silane coupling treatment layer are further ***formed on the heat-resistant layer*** or the upper layer of the heat-resistant barrier film”), [0023] (“a []material film is formed on one or both sides of a current collector substrate using copper foil with a rough surface”), [0074] (“Rust prevention treatment may be performed on the heat resistance or heat resistance barrier treatment layer. ... A rust prevention layer is obtained by forming a thin layer with a passivation function... As an organic film, in addition to benzotriazoles... As an inorganic film, a thin chromate layer... is preferably used... ***it prevents environmental deterioration of the copper foil during the period from manufacturing the copper foil of the current collector substrate to forming the active material film***, and also helps with heat resistance during active material film formation. Additionally, a silane coupling treatment layer ***may be formed on the rust prevention treatment***

layer or the heat resistance treatment layer to improve adhesion between the heat resistance treatment layer or the current collector and the silicone-based active material film”), [0092]-[0093].

116. Further, it is my opinion that it would’ve been obvious for a POSITA to apply the protective layer to both surfaces of the copper foil when a POSITA aims to achieve corrosion protection of the copper foil surface of the current collector, which would obviously be applied between it and the active material of the electrode of a secondary battery. And Toshio discloses that these layers are applied via immersion. *Id.* at [0074]. A POSITA would have understood that when a copper foil is immersed into a solution, it is coated on both sides unless selective masking, or the like is used to prevent it. This masking would be expensive, would add unnecessary complication, and would result in reduced performance as only one side of the copper foil would be protected in a secondary battery application.

117. Alternatively/additionally, as described above with respect to the Overview of Kim section, Kim describes use of a protective layer over copper foil surface at least for purposes of preventing corrosion, and it would have been obvious for a POSITA to apply the protective layer to both surfaces of the copper foil in order to achieve the same anti-corrosion effect on both surfaces of the copper foil. *See* discussion *supra* section Overview of Kim; SOLUS-1012, [0007] (“Also, the electrodeposited copper foil is additionally coated with a protective

layer at a post-processing so as to ensure corrosion resistance”), [0024] (“the surface of the copper foil is chromated to prevent corrosion”), [0025] (“As the plating conditions to obtain the crystalline structure, copper is electrodeposited onto a drum surface of a foil . . . and a nodule is formed thereat as necessary. After that, the surface of the copper foil is finally chromated to prevent corrosion”), [0028].

(iii) Claim 9

[9] The electrode according to claim 7, wherein the current collector further comprises a protective layer comprising at least one of chromate, benzotriazole and a silane compound, and wherein the protective layer is interposed between the electrolytic copper foil and the active material layer.

118. Shinozaki and Toshio (or Kim) combination renders obvious this limitation.

119. As described above with respect to discussion of claim 6, Toshio describes that [1] active material layer is formed on both surfaces of the current collector substrate and [2] protective layer such as anti-rust layer or corrosion-proof layer is applied in between the copper foil surfaces of the current collector and the active material layer. *See* [6].

120. Moreover, as described above with respect to discussion of overview of Toshio, Toshio teaches using a protective layer such as *a chromate layer, a benzotriazole layer, or a silane coupling treatment layer* on the copper foil and describes advantages including heat resistance, rust prevention, and adhesion

enhancement. *See* discussion *supra* section Overview of Toshio; *see* SOLUS-1014, [0074], [0092]-[0093], [0111], [0131], [0141], [0175], [0192], [0199], [0216].

121. Alternatively/additionally, Kim describes a *chromated surface* or a protective layer including *chromate* on the copper foil surface, *before applying the active material layer*. *See* discussion *supra* section Overview of Kim; SOLUS-1012, [0007] (“the electrodeposited *copper foil* is additionally *coated with a protective layer* at a post-processing so as *to ensure corrosion resistance*”, “In the lithium secondary battery, a copper foil is mostly used as material of the anode current collector, and *the copper foil is generally coated with active material* such as carbon-based slurry”), [0024] (“copper is electrodeposited on a drum surface of a foil making machine . . . and the surface of the copper foil is *chromated to prevent corrosion*”), [0025] (“As the plating conditions to obtain the crystalline structure, copper is electrodeposited onto a drum surface of a foil making machine . . . and a nodule is formed thereat as necessary. *After that*, the surface of the *copper foil is finally chromated to prevent corrosion*”).

(iv) Claim 11

[11] The secondary battery according to claim 10, further comprising a protective layer comprising at least one of chromate, benzotriazole and a

silane compound, wherein the protective layer is interposed between the electrolytic copper foil and the active material layer.

122. As described above with respect to discussion of limitations of claim 5 (e.g., [5b]-[5c]), claim 6, and claim 9, Shinozaki and Toshio (or Kim) combination renders obvious this limitation. See [5b]-[5c], [6], [9].

C. [GROUND 2A] – CLAIMS 1-4, 7, 8, and 10 ARE OBVIOUS OVER SANO AND GRIESI

Overview of Sano

123. Sano describes an untreated electrolytic copper foil “with low roughness surface whose surface roughness (Rz) is 2.0 μm or less,” which is applicable to both printed circuit board (PCB) and current collector for electrodes of secondary batteries. SOLUS-1008, Abstract, [0001], [0014], [0066] (“According to the present invention, it is possible to provide an electrodeposited copper foil with low roughness surface (electrodeposited copper foil, without treatment) suitably applied to printed-wiring boards or [negative electrode current] collectors of lithium secondary battery, having a roughness surface whose surface roughness Rz is 2.0 μm or less”).

124. Sano describes the need for an electrolytic copper foil⁹ having [1] low surface roughness, [2] uniformity of such low surface roughness over the surface, and [3] minimal surface profile difference between the two surfaces (shiny surface and matte surface) at the same time. *See id.*, [0005], [0006], [0012], [0013]. Sano also focuses on addressing such need by providing an electrolytic copper foil having [1] Rz value of 2.0 μm or less and [2] surface uniformity with minimized irregularities. *See id.*, Abstract, [0014], [0016].

125. Sano further describes that it was “within the conventional knowledge” to produce electrolytic copper foils where “the difference in roughness between gloss surface and roughness surface can be made as small as possible,” SOLUS-1008, [0008].

⁹ Sano refers to electrolytic copper foil for use as a current collector in the negative electrode. In Sano, the terms “anode” and “cathode” are used in the opposite manner from how they are commonly understood by a POSITA in the U.S., a convention often seen in foreign inventions or applications where naming conventions may differ. However, it would have been obvious to a POSITA that electrolytic copper foil is used as a current collector for the negative electrode in a secondary battery. As such, the “cathode” in Sano would be understood as the negative electrode.

Overview of Griesi

126. Griesi proposes a method for accurately measuring the geometric properties of the copper foil's surface such that an estimation can be used to estimate the impact of copper foil surface roughness on conductor loss. SOLUS-1015, Abstract.

127. Griesi describes the use of a treated electrolytic copper foil and further explains that production of such treated electrolytic copper foil includes [1] production of untreated electrolytic copper foil and [2] surface-treatment of the untreated electrolytic copper foil. SOLUS-1015, 27 (“As concluded in Section 2.3, it is necessary to examine the surfaces of the conductors used in high-speed PCB design. This is almost always a form of electrodeposited (ED) copper foil for its dimensional consistency, peel strength, and electrical characteristics. Today's manufacturer's use 3 main phases to fabricate these foils (Figure 2.7)”), FIG. 2.7 (reproduced below).

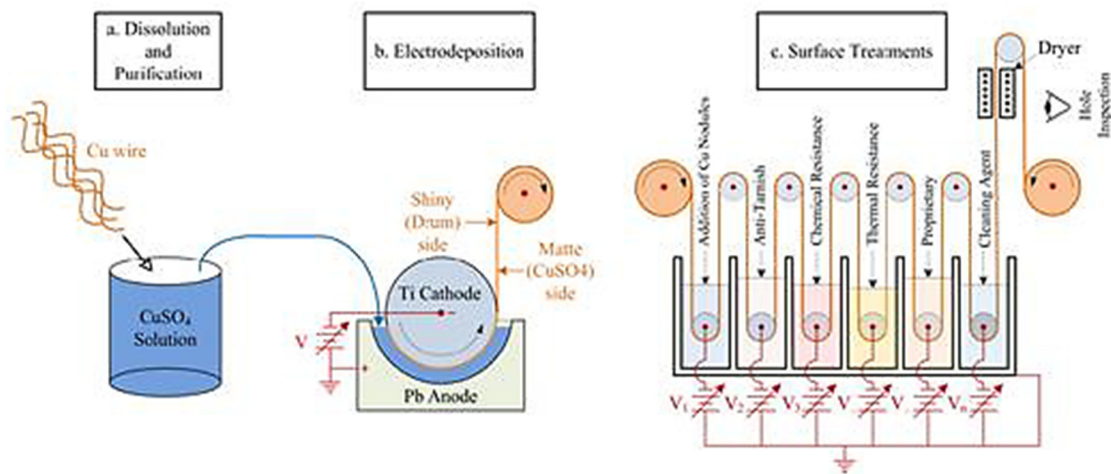


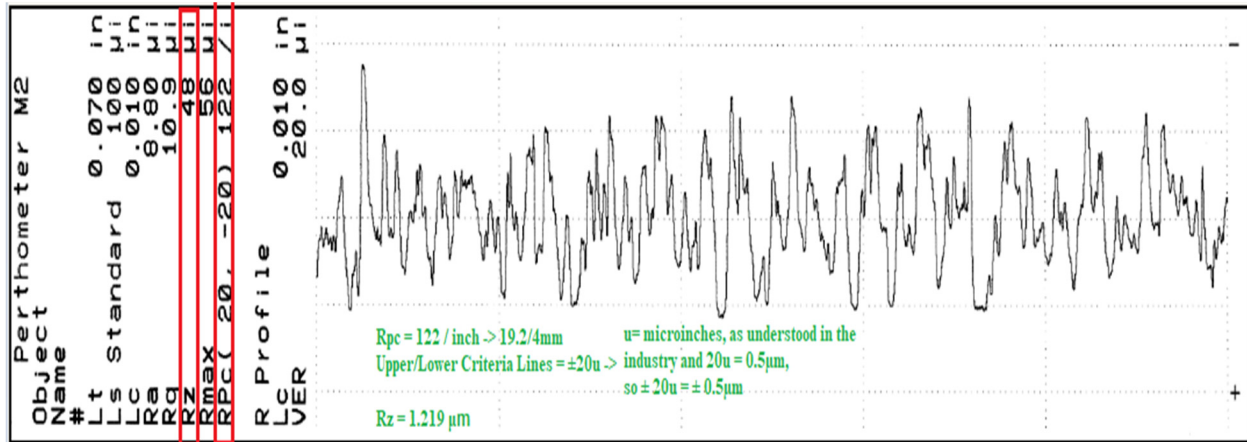
Figure 2.7 Three phases of ED copper foil fabrication. [9]

SOLUS-1015, FIG. 2.7

128. Griesi explains that it is “necessary to examine the surfaces” of the electrolytic copper foil and further states that “the electrodeposition and surface treatment phases (b and c in Figure 2.7) play key roles in determining the surface roughness of the ED foil.” *Id.*, 27-28 (“The electrodeposition and surface treatment phases (b and c in Figure 2.7) play key roles in determining the surface roughness of the ED foil. To begin, there are 2 sides of the foil made during the electrodeposition phase; the ‘drum side’ and the ‘matte side.’ The surface roughness of the drum side (also known as the ‘shiny side’ in Figure 2.7 b) is determined by the roughness of the drum, or titanium cathode, itself. These drums are polished to have an extremely smooth surface which creates the “low profile” side of the ED foil with an average deviation in the z-axis height as low as 0.3 μm (Figure 2.8)”).

129. Griesi explains two steps in analyzing the surface: [1] analyzing the *untreated* electrolytic copper foil surface; and [2] analyzing anchor nodules of the *treated* electrolytic copper surface. *Id.*, 31 (“in order to examine and characterize the surface . . . two components must be analyzed. The first is the surface area of the untreated ED [electrodeposited] foil before anchor nodules are deposited. The second is the surface area of the anchor nodules themselves. Both analyses are necessary for accurate conductor power loss modeling”).

130. Regarding surface analysis or characterization of the *untreated* electrolytic copper foil, Griesi describes that one method is to use a “mechanical profilometer (or perthometer) to measure the length, including all of the surface irregularities, in the x and y dimensions to calculate the area.” *Id.*, 51-52. Then Griesi shows an example measurement of the surface of untreated copper foil, as described in below reproduced figure 3.16 of Griesi (or figure on p. 19 of Griesi Presentation) with annotations. *See id.*, 53-54, FIG. 3.16 or SOLUS-1029, 18-19 (reproduced below, annotated).



SOLUS-1015, FIG. 3.16; SOLUS-1029, 18-19

131. As explained in the above figure 3.16 of Griesi with annotations, Griesi's untreated electrolytic copper foil surface shows surface roughness parameter values including $R_z = 1.2 \mu\text{m}$ (e.g., $48 \mu\text{in}$) and $R_{pc} = 19.2$ (e.g., 122 peaks per inch = 19.2 peaks per 4 mm sampling length, and with upper and lower criteria lines of $+20 \mu\text{in}$, and $-20 \mu\text{in}$ ($+0.5 \mu\text{m}$ and $-0.5 \mu\text{m}$)).

Reasons for the combination

132. Sano explicitly confirms the well-known use of [1] *untreated* electrolytic copper foil and [2] its use compatibility between the PCB and secondary battery collector. Sano teaches producing the *untreated* electrolytic copper foil with surfaces having an $R_z \leq 2 \mu\text{m}$ and surface uniformity with minimized irregularities, which are advantageous and applicable for the PCB or the current collectors of lithium secondary battery. SOLUS-1008, [0001], [0006], [0012], [0013], [0055], [0057], [0059], [0061], [0062], [0066]; *see also* SOLUS-

1030, [0025], [0043], [0104], [0107], [0108]; *see also* SOLUS-1031, [0038], [0052].

133. Similarly, Griesi describes the [1] *untreated* electrolytic copper foil for use in PCB and [2] Rz value that is less than 2 μm . For instance, above reproduced figure 3.16 of Griesi, with annotations, describes an Rz value of 1.2 μm . SOLUS-1015, 53-54.

134. Accordingly, based on the teachings of Sano set forth above, it is my opinion that a POSITA looking to further optimize Sano's copper foil surface (which can serve as a starting point) would have considered Griesi's surface roughness profile data (including **Rz** value of 1.2 μm) of the *untreated* electrolytic copper foil and would have recognized the similarities between Sano and Griesi's copper foil surfaces. A POSITA would have also recognized another surface roughness-related parameter, R_{pc}, in Griesi as a potentially useful parameter that can be optimized to further enhance uniformity or generally improve Sano's copper foil surface.

135. In fact, R_{pc} was a generally known spacing parameter that could be controlled to obtain better bonding of finishes and a more uniform finish of the electrolytic copper foil surface. SOLUS-1016, 7 ("By controlling spacing parameters [e.g., R_{pc}] it is possible to obtain better bounding of finishes, more uniform finish of plating").

136. Further, prior art indicates that Rpc was a recognized, result-effective variable known to be correlated with enhancing surface roughness characteristics and providing void-reduced, uniform copper deposits. *See* discussion *supra* Part IV.A.1.(i).[1c]-[1e].

137. Therefore, in the combination, based on disclosure of Sano and Griesi in view of common and prior knowledge, it would have been obvious for a POSITA to optimize Rpc through routine experimentation to arrive at the claimed range of Rpc.

138. Further, it is my opinion that a POSITA would have expected success in optimizing the Rpc through routine experimentation, at least for the reasons described above with respect to discussion of claim limitation [1c]-[1e] in Ground 1A. *See* discussion *supra* Part VII.A.1.(i).[1c]-[1e]. For instance, the optimization of Rpc would have involved mere routine adjustments of electrolysis conditions, such as varying concentrations of additives, treatment time, and current density.

139. Additionally, prior art and generally known knowledge suggest that achieving values within the claimed range (Rpc of 10-100) would be straightforward. The viability and possibility of such values are evidenced at least by Griesi and Fabian (e.g., Rpc = 19.2 in Griesi, Rpc of 33.1, 33.3 in Fabian). *See* discussion *supra* Part VII.A.1.(i).[1c]-[1e]; *see* SOLUS-1015, FIG. 3.16. For example, as described above, Griesi shows Rpc value of 19.2 per 4 mm sampling

length. In the surface profile data of FIG. 3.16, units for Rz and R_{pc} are in microinches (μin). As commonly understood in the materials industry, 20μin = 0.5μm. Accordingly, as described above, *R_{pc} (20 μin upper criteria line, -20 μin lower criteria line) = 122 / μin* can be converted to *R_{pc} (0.5μm upper criteria line, -0.5 μm lower criteria line) = 19.2 / 4mm*).

1. Claim-by-Claim Analysis

(i) Claim 1

[1pre] An electrolytic copper foil for a secondary battery, the electrolytic copper foil comprising:

140. As described above with respect to the discussion of reasons for the combination, Sano's electrolytic copper foil can be used for the current collector for electrodes of secondary batteries. SOLUS-1008, [0001], [0066]; *see* discussion *supra* Part VII.C.1

[1a] a first surface; and

[1b] a second surface opposite to the first surface,

141. The Sano-Griesi combination renders obvious [1a]-[1b]. For example, in the combination, Sano describes the shiny surface and the matte surface. SOLUS-1008, [0003] ("In the present description, the face of electrodeposited copper foil that has contacted the drum surface is referred to as "gloss surface" and the face opposite to the gloss surface is referred to as "roughness surface").

142. Further, a POSITA would have known that, as conventional knowledge, electrolytic untreated copper foil has both a shiny surface and a matte surface opposite the shiny surface.

[1c] wherein each of the first and second surfaces has a peak count roughness R_{pc} of 10 to 100,

[1d] wherein the peak count roughness R_{pc} of each of the first and second surfaces is an average of peak count roughness R_{pc} values measured at randomly-selected three points,

[1e] the peak count roughness R_{pc} of each point is the number of effective peaks which rise above an upper criteria line of 0.5 μm per unit sampling length of 4 mm in a surface roughness profile obtained according to steel iron test schedule (SEP 1940), and there is at least one valley deeper than a lower criteria line of -0.5 μm between adjacent ones of the effective peaks.

143. At least for the reasons described below, the Sano-Griesi combination renders obvious [1c]-[1e].

144. First, as described above with respect to discussion of Ground 1A (Section VII.A.1.), R_{pc} (peak count roughness) is a recognized measurement shared among different standards. *See* discussion *supra* Part VII.A.1.(i).(1e).

145. Second, in the combination, as described above with respect to discussion of reasons for the combination, based on disclosure of Sano and Griesi in view of common and prior knowledge, it is my opinion that, it would have been obvious for a POSITA to optimize R_{pc} of Sano's electrolytic copper foil surfaces through routine experimentation to arrive at the claimed range of R_{pc}. *See id.*

147. Alternatively, this specific *Rpc* value of 19.2 disclosed in Griesi is a relevant disclosure for the recited range of *Rpc* values.

148. Regarding limitation [1d], as described above, a POSITA would find it obvious and reasonable to make such random measurements over at least three randomly selected points or locations, in order to reduce sampling bias. See ¶59. The surface roughness manual generally explains that surface roughness parameters are measured according to randomly sampled places. See SOLUS-1017, 3 (explaining that surface roughness parameters correspond to “the parameters expressing the surface roughness at each part sampled randomly from the surface”). Indeed, the Standard (JIS-B-0601-1994) discloses the use of random sampling throughout. See, *e.g.*, *id.* 3, 10, 12, 15, 18, 21, 24, 27.

149. Third, in the combination, both *shiny and matte surfaces* would have a *peak count roughness Rpc of 10 to 100*. As explained in Sano, “[i]t is within the conventional knowledge that in a process for producing an electrodeposited copper foil . . . the difference in roughness between gloss surface and roughness surface can be made as small as possible.” SOLUS-1008, [0008]. Further, it would have been obvious for a POSITA, aiming to produce electrolytic copper foil for use in either secondary batteries or PCB, to minimize the surface roughness differences between the two surfaces. This would have ensured a consistent battery reaction (*e.g.*, so as to prevent the drop in the charge/discharge efficiency of the battery, and

the like) and would have improved circuit accuracy. SOLUS-1008, [0006]; SOLUS-1004, [0004]. Accordingly, a POSITA would have been motivated to produce both surfaces that exhibit similar surface profiles, including roughness characteristics. Therefore, in the combination, both surfaces would exhibit similar R_{pc} values, each falling within the claimed range of “10 to 100.”

150. Thus, at least for the reasons set forth above, the combination of Sano-Griesi renders obvious the electrolytic copper foil having a first surface and a second surface with “R_{pc} of 10 to 100.”

(ii) Claim 2

[2] The electrolytic copper foil according to claim 1, wherein a difference in peak count roughness R_{pc} between the first and second surfaces is 60 or less.

151. As described above, Sano-Griesi combination, in view of common and prior knowledge, renders obvious the limitation that both surfaces of electrolytic copper foil have an “R_{pc} of 10 to 100.” *See* [1c]-[1e].

152. Further, as described above, [1] the Sano-Griesi combination describes the need for having both surfaces (shiny surface and matte surface) of the electrolytic copper foil to exhibit similar surface characteristics, [2] it was conventional to process both sides to exhibit similar surface roughness characteristics, and [3] it was commonly known that similar surface characteristics on both sides of copper foil facilitate bonding between current collector and active material layer, which directly impacts battery performance. *See* SOLUS-1004,

[0004], [0073], [0074], [0122]; *see* SOLUS-1008, [0005], [0006], [0008]; *see* SOLUS-1009, 1:12-18; *see* discussion *supra* Part VII.C.1.(i).

153. Therefore, it is my opinion that a POSITA would have been motivated to produce both surfaces to exhibit similar surface profiles, including surface roughness-related characteristics.

154. Because shiny and matte surfaces exhibit similar surface profiles, a difference in peak count roughness R_{pc} between the first and second surfaces would be 60 or less, especially since the R_{pc} value disclosed in Griesi (e.g., 19.2 per sampling length of 4 mm) is itself less than 60 it is highly likely that the difference in R_{pc} between the sides would be even smaller than 19.2, which is less than 60. As such, Sano-Griesi renders obvious this claim limitation.

(iii) Claim 3

[3] The electrolytic copper foil according to claim 1, wherein each of the first and second surfaces has a ten-point mean roughness R_{zJIS} of 2 μm or less.

155. As described above with respect to the discussion of reasons for the combination section, Sano-Griesi in combination describes the electrolytic copper foil surface having $R_z \leq 2 \mu\text{m}$ and both surfaces exhibiting similar roughness characteristics. *See* discussion *supra* Part VII.C.1.

156. Therefore, Sano-Griesi renders obvious the electrolytic copper foil having both surfaces with R_{zJIS} of 2 μm or less. *See* [1c]-[1e], [2].

(iv) Claim 4

[4] The electrolytic copper foil according to claim 1, wherein the electrolytic copper foil has a thickness of 3 to 20 μ m and tensile strength of 30 to 60 kgf/mm²

157. First, regarding the thickness of 3 to 20 μ m, Sano-Griesi combination renders this limitation obvious. More specifically, Sano describes the need for the electrolytic copper foil having “a small thickness” and obtaining the copper foil with the “thickness of 18 μ m,” which falls within the claimed range. SOLUS-1008, [0005] (“electrodeposited copper foil . . . having a small thickness is requested”), [0054], [0062], [0059] (“An electrodeposited copper foil having a thickness of 18 μ m was obtained in the same conditions as employed in the above best mode for carrying out the invention”).

158. Second, regarding the tensile strength of 30 to 60 kgf/mm², the Sano-Griesi combination renders this limitation obvious. In particular, Sano describes a tensile strength range of 350-500 MPa (corresponding to 36.7-51.0 kgf/mm²), shown in the examples that fall within the teachings of Sano. SOLUS-1008, [0055], [0059], [0061], Table 2 (disclosing Examples 1-7, all having “Expansive force (MPa)” values of 350-500 MPa or 36.7-51.0 kgf/mm²).

159. Alternatively/additionally, tensile strength of 30 to 60 kgf/mm² indicates a relatively wide range. Based on common and prior knowledge in the field, not only most of the electrolytic copper foil used for the copper collector of

secondary batteries would fall within this range, but also it was conventional to produce or obtain electrolytic copper foils that fall within this tensile strength range. SOLUS-1004, [0050] (suggesting electrolytic copper foil with tensile strength of 300 N/mm² or 30.59kgf/mm²), Table 2 (listing tensile strength of electrolytic copper foil ranging from 310 to 400 N/mm² or 31.6 kgf/mm² to 40.8 kgf/mm²); SOLUS-1008, Table 2 (listing tensile strength of 17 examples of electrolytic copper foil ranging from 335MPa (34.15 kgf/mm²) to 500 MPa (51.0 kgf/mm²); SOLUS-1009, Table 2 (listing tensile strength of electrolytic copper foil ranging from 33.6 kgf/mm² to 37.2 kgf/mm²); SOLUS-1026, claim 5, [0018], [0050], [0051] (“As for the mechanical properties of the electrolytic copper foil incorporated into the present invention, the tensile strength under normal conditions is 33 kgf/mm² or more”).

160. Accordingly, Sano-Griesi in view of common and prior knowledge renders obvious this limitation.

(v) Claim 7

[7pre] An electrode for a secondary battery, the electrode comprising:

161. *See* discussion *supra* section [1pre].

[7a] a current collector comprising the electrolytic copper foil according to claim 1; and

162. As described above with respect to the discussion of reasons for the combination, Sano's electrolytic copper foil can be used for current collector for electrodes of the secondary batteries. *See* discussion *supra* Part VII.C; SOLUS-1008, [0001], [0066].

[7b] an active material layer disposed on the current collector;

163. Although this limitation is not explicitly disclosed in Sano (or Griesi), this is an inherent and otherwise obvious limitation that would have been known to a POSITA. Indeed, it was common knowledge that such active material or active material layer is essential for functioning of the secondary battery, for example, for operation of the battery's electrochemical reactions during charging and discharging processes.

164. Moreover, as described above with respect to claim limitation [7b] of Ground 1, prior art (Shinozaki) confirms the prior and common knowledge relating to the active material layer being disposed on the current collector. SOLUS-1004, [0038].

165. Therefore, the combination renders obvious this limitation in view of common and prior knowledge.

[7c] wherein the active material layer comprises at least one active material selected from the group consisting of: carbon; a metal (Me) of Si, Ge, Sn, Li,

Zn, Mg, Cd, Ce, Ni or Fe; an alloy containing the metal; an oxide of the metal (MeOx); and a chemical compound of the metal and carbon.

166. As described above with respect to discussion of [7b], it was common knowledge that this active material or active material layer is essential for functioning of the secondary battery, for example, for operation of a battery's electrochemical reactions during charging and discharging processes.

167. Moreover, it was already disclosed that silicon, germanium, tin, or an alloyed compound thereof could be used as one or more of active materials. SOLUS-1004, [0038] (“The electrolytic copper foil for lithium ion secondary battery is used as the collector, and the active material which is deposited on its surface is comprised of primary particles of silicon, germanium, or tin or an alloyed compound of the same or of secondary particles which are obtained by processing the primary particles”).

168. Accordingly, the combination renders obvious this limitation in view of common and prior knowledge.

(vi) Claim 8

[8] The electrode according to claim 7, wherein the active material layer comprises Si.

169. As described above with respect to discussion of [7c], it was already disclosed that silicon, germanium, tin, or an alloyed compound thereof can be used as one or more of active materials. SOLUS-1004, [0038].

(vii) Claim 10

[10pre] A secondary battery comprising:

170. *See* discussion *supra* section [1pre].

[10a] a cathode; an anode; an electrolyte for providing an environment enabling lithium ions to move between the cathode and the anode; and a separator for electrically insulating the cathode from the anode,

171. This limitation relates to conventional knowledge.

172. For example, as explained in prior art, it was conventional [1] for a secondary battery to have a cathode, an anode, and an electrolyte, [2] that the electrolyte is “for providing an environment enabling lithium ions to move between the cathode and the anode” and [3] the secondary battery would have a separator for electrically insulating the cathode from the anode. SOLUS-1012, [0006] (“A lithium secondary battery generally includes a cathode and an anode, which are arranged with a separator being interposed between them, and an electrolyte”).

[10b] wherein the anode comprises: a current collector comprising the electrolytic copper foil according to claim 1; and

173. *See* discussion *supra* claim 1, 7.

[10c] an active material layer disposed on the current collector.

174. As described above, a POSITA would have found this limitation to be obvious in view of Sano. As described above, numerous other prior art references,

such as Shinozaki, *etc.*, confirm the prior and common knowledge relating to the active material layer being disposed on the current collector. *See, e.g.*, SOLUS-1004, [0029], [0038], [0040]; *see* [7b].

D. [GROUND 2B] – CLAIMS 5, 6, 9, and 11 ARE OBVIOUS OVER SANO, GRIESI, AND TOSHIO (OR KIM)

Reasons for the combination

175. As described above, in the Sano-Griesi combination, Sano's untreated electrolytic copper foil can be used for a secondary battery current collector.

176. Further, as described above with respect to discussion of reasons for the combination section for Ground 1B, Toshio and Kim describe that using a protective layer such as a chromate layer, a benzotriazole layer, or a silane coupling treatment layer on the copper foil provides many advantages including heat resistance, rust prevention, corrosion prevention, and adhesion enhancement. *See* discussion *supra* Part VII.B.

177. Accordingly, at least for the reasons described below, it would have been obvious for a POSITA to apply a protective layer to the untreated copper foil of Sano, either with or without surface treatment, with the expectation of success.

178. First, as described above, Toshio and Kim describe advantages of applying a protective layer to the copper foil for use in current collectors. *Id.* For instance, Toshio describes that using a protective layer such as a chromate layer, a

benzotriazole layer, or a silane coupling treatment layer on the copper foil provides many advantages including heat resistance, rust prevention, and adhesion enhancement. *Id.*; SOLUS-1014, [0074], [0092]-[0093], [0111], [0131], [0141], [0175], [0192], [0199], [0216]. Further, for instance, as described above, Kim further describes that using a protective layer including a chromate layer provides advantages including corrosion prevention. SOLUS-1012, [0007], [0024], [0025], [0028].

179. Second, Kim describes that such protective layer coating can be applied to the untreated copper foil, either with or without treatment. *Id.*, [0025] (“As the plating conditions to obtain the crystalline structure, copper is electrodeposited onto a drum surface of a foil making machine with a current density of 30 to 80 ASD at a temperature of 30 to 60° C. to make an original foil, and a nodule is formed thereat as necessary. After that, the surface of the copper foil is finally chromated to prevent corrosion”).

180. Third, it is my opinion that applying one or more layers (e.g., protective layers) including a chromate layer, a benzotriazole layer, an adhesion promoting layer, or a silane coupling treatment layer on the copper foil was well-known and conventional. *See e.g.*, FIG. 2.7 of SOLUS-1015 above, noting immersion type “C. Surface Treatments” on the electrodeposited copper foil for “Anti-tarnish” and “Chemical Resistance”, etc.

(i) Claim 5

[5pre] A current collector for a secondary battery, the current collector comprising:

181. As described above with respect to the discussion of reasons for the combination in Ground 2A, Sano's electrolytic copper foil can be used for a current collector for electrodes of the secondary batteries. *See discussion supra* Part VII.C; SOLUS-1008, [0001], [0066].

[5a] the electrolytic copper foil according to claim 1; and

182. *See discussion supra* claim 1.

[5b] a protective layer disposed on the electrolytic copper foil,

[5c] wherein the protective layer comprises at least one of chromate, benzotriazole and a silane compound.

183. In the combination (Sano, Griesi, and Toshio or Kim), Toshio or Kim renders obvious [5b]-[5c].

184. For similar reasons with respect to those discussed above regarding claim 5 in Ground 1B, Toshio or Kim teaches such protective layer(s) that can be applied to the electrolytic copper foil surface. *See discussion supra* Part VII. B.

(ii) Claim 6

[6] The current collector according to claim 5, wherein the protective layer is formed on the first and second surfaces of the electrolytic copper foil.

185. In the combination (Sano, Griesi, and Toshio or Kim), Toshio or Kim renders obvious this limitation.

186. As described above with respect to claim 6 in Ground 1B, Toshio or Kim teaches that the protective layer can be formed on the first and second surfaces of the electrolytic copper foil. *See* discussion *supra* Part VII. B. Further, Fig. 2.7 of Griesi (reproduced above) indicates that the “Surface Treatments” are on both sides of the copper foil.

(iii) Claim 9

[9] The electrode according to claim 7, wherein the current collector further comprises a protective layer comprising at least one of chromate, benzotriazole and a silane compound, and wherein the protective layer is interposed between the electrolytic copper foil and the active material layer.

187. In the combination (Sano, Griesi, and Toshio or Kim), Toshio or Kim renders obvious this limitation.

188. For similar reasons with respect to those discussed above regarding claim 9 in Ground 1B, Toshio or Kim renders this limitation obvious. *See* discussion *supra* Part VII. B.

(iv) Claim 11

[11] The secondary battery according to claim 10, further comprising a protective layer comprising at least one of chromate, benzotriazole and a silane compound, wherein the protective layer is interposed between the electrolytic copper foil and the active material layer.

189. In the combination (Sano, Griesi, and Toshio or Kim), Toshio or Kim renders obvious this limitation.

190. For similar reasons with respect to those discussed above regarding claim 11 in Ground 1B, Toshio or Kim renders this limitation obvious. *See* discussion *supra* Part VII. B.

E. [GROUND 3] – CLAIMS 1-11 ARE OBVIOUS OVER DOBASHI

Overview of Dobashi

191. Dobashi describes an electrolytic copper foil for use in both PCB and secondary batteries. SOLUS-1007, [0001], [0107].

192. Dobashi describes that an object is “to provide a surface-treated electro-deposited copper foil which has a low profile . . . in which waviness . . . is small,” and that “the present inventors thought out a surface treated electro-deposited copper foil having a bonding surface having a low profile.” SOLUS-1007, Abstract, [0010].

193. Dobashi further describes that R_{ZJIS} adjustment enhances adhesion “when the surface-treated electro-deposited copper foil is bonded to the [] material.” SOLUS-1007, [0057].

194. Dobashi particularly attributes the low profile, small waviness, and adhesion enhancement to the following surface roughness characteristics on the deposit side (e.g., *bonding side* for material):

[1] ***The surface roughness (R_{zjis})*** (or 10-point mean roughness) of the deposit side being ***0.1- 1 μ m***. SOLUS-1007, [0065] (“The surface roughness

(Rzjis) of the deposit side of the electro-deposited copper foil is preferably 0.1 μm to 1.0 μm ”), Abstract, claim 3;

[2] ***PV = 0.05-1.5 μm . Id.***, Abstract, claim 4, [0056] (“The maximum peak to valley height (PV) used as one of indicators for detecting the surface shape in the present invention is the sum of the maximum peak height and maximum valley depth of the sample surface”), [0056] (“The maximum peak to valley height (PV) of the bonding surface of the surface-treated electro-deposited copper foil to be bonded with the [] material is preferably 0.05 μm to 1.5 μm ”);

[3] ***Rsm > 0.1 mm. Id.***, [0057] (“RSm obtained together with the measurement of Rzjis is further preferably more than 0.1”), [0048] (“RSm can also be used as an indicator for judgment of the surface. The surface has small waviness and is smooth when RSm is large, and the surface has large waviness and is rough when RSm is small.”); and

[4] ***Uniform surface of bonding side.*** SOLUS-1007, [0065].

195. In sum, Dobashi particularly attributes the adhesion enhancement to the following surface roughness characteristics:

[1] 10-point mean roughness RzJIS = 0.1-1.0 μm ;

[2] maximum peak to valley height (PV) = 0.05-1.5 μm ;

[3] Rsm > 0.1 mm; and

[4] Uniform surface of bonding side.

196. Dobashi further emphasizes that “the surface-treated electro-deposited copper foil according to the present invention can also be suitably used as the negative electrode current collector of a lithium-ion secondary battery.” SOLUS-1007, [0107].

1. Claim-by-Claim Analysis

(i) Claim 1

[1pre] An electrolytic copper foil for a secondary battery, the electrolytic copper foil comprising:

197. Dobashi describes that “the surface-treated electro-deposited copper foil according to the present invention can also be suitably used as the negative electrode current collector of a lithium ion secondary battery.” SOLUS-1007, [0107].

[1a] a first surface; and

[1b] a second surface opposite to the first surface,

198. Dobashi renders obvious [1a]-[1b]. For example, Dobashi describes surfaces of “shiny side” and “deposit side.” SOLUS-1007, [0016]-[0018], [0060]-[0066].

[1c] wherein each of the first and second surfaces has a peak count roughness R_{pc} of 10 to 100,

[1d] wherein the peak count roughness R_{pc} of each of the first and second surfaces is an average of peak count roughness R_{pc} values measured at randomly-selected three points,

[1e] the peak count roughness R_{pc} of each point is the number of effective peaks which rise above an upper criteria line of 0.5 μm per unit sampling length of 4 mm in a surface roughness profile obtained according to steel iron test schedule (SEP 1940), and there is at least one valley deeper than a lower criteria line of -0.5 μm between adjacent ones of the effective peaks.

199. At least for the reasons described below, Dobashi renders obvious [1c]-[1e].

200. First, as described above with respect to discussion of Ground 1A (Section VII.A.1.), R_{pc} (peak count roughness) is a recognized measurement shared among different standards. *See* discussion *supra* Part VII.A.1.(i).(1e).

201. Second, as described above, R_{pc} can be obtained from other surface roughness parameters such as R_{sm} or S_m. *See* discussion *supra* Part.

VII.A.1.Claim 1.

202. Third, Dobashi renders obvious this R_{pc} limitation, where Dobashi's teachings about surface roughness covers R_{pc} that fall within the claimed range. In particular, Dobashi's teachings on surface roughness characteristics that improve adhesion properties can be translated into an R_{pc} value falling within the claimed range.

203. Again, Dobashi's surface profile includes: [1] $Rz_{JIS}^{10} = 0.1-1.0 \mu m$
[2] $PV^{11} = 0.05-1.5 \mu m$ [3] $Rsm^{12} > 0.1 \mu m$.

204. The following Tables (1-3) are manually generated hypothetical surface profiles that satisfy Dobashi's teachings of Rz_{JIS} , PV , and Rsm . For instance, the below hypotheticals not only [1] align within the teachings of the Dobashi's surface characteristics (e.g., $Rz_{JIS} = 0.1-1.0 \mu m$, $PV = 0.05-1.5 \mu m$, $Rsm > 0.1 mm$) and [2] but also at the same time can be converted to Rpc values of 10, 15, and 20, which all fall within the claimed range. Therefore, the hypothetical

¹⁰ Rz_{jis} corresponds to ten-point mean roughness measure, which represents the average height of the five highest peak-to-lower valley pairs along the sampling length of a surface profile. See discussion *supra* Part IV.A.

¹¹ The maximum peak to valley height (PV) used as one of indicators for detecting the surface shape in the present invention is the sum of the maximum peak height and maximum valley depth of the sample surface. SOLUS-Dobashi, [0056].

¹² Rsm represents the average distance between pairs of consecutive peaks and valleys on a surface, and dividing the sampling length by Rsm gives the number of these peak-valley pairs within that length because it measures how many average-width segments fit into the total length. See discussion *supra* Part IV.A.1.(i).[1c]-[1e]).

surface profiles that are generated to satisfy Dobashi's teachings produce R_{pc} values within the claimed range. Therefore, Dobashi renders obvious this R_{pc} limitation, where Dobashi's teachings about surface roughness cover R_{pc} values that fall within the claimed range.

205. Table 1

	1st Data Set $R_z = 1.0 \mu\text{m}$, $PV = 1.3 \mu\text{m}$, $R_{sm} > 0.1 \text{ mm}$, sampling length $0.8\text{mm} \rightarrow R_{pc} \approx 10 / 4\text{mm}$				
5 Highest Peaks from mean line	0.50	0.65	0.55	0.45	0.35
5 Deepest Valleys from mean line	-0.50	-0.65	-0.55	-0.45	-0.35
As these are highest peaks and deepest valleys, other existing peaks cannot be higher than 0.35 and deeper than -0.35. This indicates that there can't be any more peaks that rise above $+0.5\mu\text{m}$, or descend below $-0.5 \mu\text{m}$ about the mean line in this sample (with sampling length of 0.8 mm) **So in these data it is definite that there are 2 peaks ($R_{pc} = 2$) per sampling length of 0.8 mm, and when sampling length is 4mm, $R_{pc} = 10$					

206. Table 2

	2nd Data Set $R_z = 1.0 \mu\text{m}$, $PV = 1.2 \mu\text{m}$, $R_{sm} > 0.1 \text{ mm}$, sampling length $0.8\text{mm} \rightarrow R_{pc} \approx 15 / 4\text{mm}$				
5 Highest Peaks from mean line	0.6	0.4	0.3	0.6	0.6
5 Deepest Valleys from mean line	-0.6	-0.4	-0.3	-0.6	-0.6
As these are highest peaks and deepest valleys, other existing peaks cannot be higher than 0.3 and deeper than -0.3. This indicates that there can't be any more peaks that rise above $+0.5\mu\text{m}$, or descend below $-0.5 \mu\text{m}$ about the mean line in this sample (with sampling length of 0.8 mm) **So in these data it is definite that there are 3 peaks ($R_{pc} = 3$) per sampling length of 0.8 mm, and when sampling length is 4mm, $R_{pc} = 15$					

207. Table 3

	<u>3rd Data Set</u>				
	Rz = 1.0 μ m, PV = 1.1 μ m, Rsm > 0.1 mm, sampling length 0.8mm $\rightarrow$ Rpc $\approx$ 20 / 4mm				
5 Highest Peaks from mean line	0.55	0.55	0.55	0.55	0.3
5 Deepest Valleys from mean line	-0.55	-0.55	-0.55	-0.55	-0.3
As these are highest peaks and deepest valleys, other existing peaks cannot be higher than 0.3 and deeper than -0.3. This indicates that there can't be any more peaks that rise above +0.5 μ m, or descend below -0.5 μ m about the mean line in this sample (with sampling length of 0.8 mm). **So in these data it is definite that there are 4 peaks (Rpc= 4) per sampling length of 0.8 mm, and when sampling length is 4mm, Rpc =20					

208. Furthermore, as described above, Rpc was a recognized, result-effective variable known to be correlated with enhancing surface roughness characteristics and providing void-reduced, uniform copper deposits. It is my opinion that a POSITA would have been motivated to optimize Rpc to obtain “electro-deposited copper foil having a good surface condition,” which, as taught in Dobashi, requires the bonding surface of the copper foil to be “uniform.” SOLUS-1007, [0065]. Moreover, as described above, such optimization would have involved routine experimentation, and it is my opinion that a POSITA would have expected success. *See* discussion *supra* Part VII.A.1.(i).[1c]-[1e]; *see also* discussion *supra* Part VII.C. Therefore, it would have been obvious for a POSITA to optimize Rpc to arrive at the claimed range of Rpc.

209. Regarding limitation [1d], as described above, a POSITA would find it obvious and reasonable to make such random measurements over at least three

randomly selected points or locations, in order to reduce sampling bias. *See* ¶59.

The surface roughness manual generally explains that surface roughness parameters are measured according to randomly sampled places. *See* SOLUS-1017, 3 (explaining that surface roughness parameters correspond to “the parameters expressing the surface roughness at each part sampled randomly from the surface”). Indeed, the Standard (JIS-B-0601-1994) discloses the use of random sampling throughout. *See, e.g., id.* 3, 10, 12, 15, 18, 21, 24, 27.

210. Also, as noted above, Dobashi’s teachings on surface roughness characteristics pertain to the “bonding surface of the surface-treated electro-deposited copper foil.” Accordingly, a POSITA would have understood that when Dobashi’s electrolytic copper foil is used as a current collector for the negative electrode in batteries, these teachings would apply to both sides of the foil. This is because, typically both sides of the electrolytic copper foil are bonding sides that adhere to the active material layer, directly impacting the battery's performance.

211. To the extent that Dobashi discloses any surface profile or roughness parameter values measured after rust-proofing treatment or silane coupling agent treatment, such values would remain unaffected or be affected only to a negligible extent. For example, Tables 2 and 4 of Dobashi demonstrate this, showing surface profile or roughness parameters before and after these treatments are performed on the copper foil surface. SOLUS-1007, Tables 2, 4.

(ii) Claim 2

[2] The electrolytic copper foil according to claim 1, wherein a difference in peak count roughness R_{pc} between the first and second surfaces is 60 or less.

212. At least for the following reasons, Dobashi in view of well-known knowledge in the field of secondary batteries renders this claim limitation obvious.

213. As evidenced by numerous prior art, a POSITA would have been aware of making both surfaces (e.g., from the matte side and the shiny side) to exhibit similar surface characteristics to thereby facilitate bonding between current collector and active material layer. *See* SOLUS-1004, [0004], [0073], [0074], [0122]; *see* SOLUS-1008, [0005], [0008]; *see* SOLUS-1009, 1:12-18.

214. Further, as described above, Dobashi's teachings on surface roughness characteristics pertain to the "bonding surface of the surface-treated electro-deposited copper foil." Accordingly, a POSITA would have understood that when Dobashi's electrolytic copper foil is used as a current collector for the negative electrode in batteries, these teachings would apply to both sides of the foil. This is because, typically both sides adhere to the active material layer, directly impacting the battery's performance.

215. Accordingly, because shiny and matte surfaces exhibit similar surface profiles, and because Dobashi teaches criteria (e.g., $R_{sm} > 0.1$ mm) that limit the maximum peak count to 40 or less per 4 mm sampling length, thus the difference in peak count roughness R_{pc} between the first and second surfaces would

necessarily be ≤ 40 , and 60 is more than 40, thereby mandating that the difference in peak count R_{pc} be 60 or less. Therefore, Dobashi in view of common and prior knowledge renders obvious this limitation.

(iii) Claim 3

[3] The electrolytic copper foil according to claim 1, wherein each of the first and second surfaces has a ten-point mean roughness R_{zJIS} of 2 μm or less.

216. As described above with respect to the overview of Dobashi, Dobashi teaches R_{zjis} of the bonding side being 0.1- 1 μm . SOLUS-1007, [0065] (“The surface roughness (R_{zjis}) of the deposit side of the electro-deposited copper foil is preferably 0.1 μm to 1.0 μm ”), Abstract, claim 3.

217. Because shiny and matte surfaces would exhibit similar surface profiles, as described above with respect to the discussion of claims 1 and 2, Dobashi renders obvious this limitation.

(iv) Claim 4

[4] The electrolytic copper foil according to claim 1, wherein the electrolytic copper foil has a thickness of 3 to 20 μm and tensile strength of 30 to 60 kgf/mm^2

218. First, Dobashi provides guidance for producing electrolytic copper foils that have thickness less than 20 μm and discloses examples of electrolytic copper foils having thickness of 12 and 15 μm . SOLUS-1007, [0062], Table 2. Thus, Dobashi renders obvious this limitation.

219. Second, tensile strength of 30 to 60 kgf/mm² indicates a wide range. Based on common and prior knowledge in the field, most of the electrolytic copper foil used for the copper collector of secondary batteries would fall within this range. Moreover, it was conventional to produce or obtain electrolytic copper foils that fall within this tensile strength range. SOLUS-1004, [0050] (disclosing that it is preferably to have electrolytic copper foil with tensile strength of $\geq 30.61 \text{ kgf/mm}^2$), Table 2 (listing tensile strength of electrolytic copper foil ranging from 31.6 kgf/mm² to 40.8 kgf/mm²); SOLUS-1008, Table 2 (listing tensile strength of 17 examples of electrolytic copper foil ranging from 335MPa (34.2 kgf/mm²) to 500MPa (51.0 kgf/mm²); SOLUS-1009, Table 2 (listing tensile strength of electrolytic copper foil ranging from 33.6 kgf/mm² to 37.2 kgf/mm²); SOLUS-1026, claim 5, [0018], [0050], [0051] (“As for the mechanical properties of the electrolytic copper foil incorporated into the present invention, the tensile strength under normal conditions is 33 kgf/mm² or more”), [0051] (“by optimizing the manufacturing conditions, it is possible to have superior mechanical properties such as a normal tensile strength of 38 kgf/mm² or more and a tensile strength of 33 kgf/mm² or more after heating (180°C × 60 minutes, atmosphere)”). Further, it is my opinion that it was conventional to vary the electrolyte concentration, electrolysis conditions, and/or the deposition conditions to obtain a copper foil

with tensile strength falling within the claimed tensile strength range as this range was well known, at least since 1974, as illustrated below.

Table 2. PROPERTIES OF COPPER ELECTRODEPOSITS USEFUL FOR DIVERSE APPLICATIONS

Outstanding Characteristic	Tensile Strength, kg/mm ²	Elongation, % (5cm)	Internal Stress, ^c kg/mm ²	Hardness (VHN ₂₀₀), kg/mm ²	Electrical Resistivity, microhm-cm
High strength	45-63.5	4-18	-4.2 or 3.6 to 5.5	131-159	1.75-2.02
Hardness	3.5-55.5	0-10	-4.2 or 3.0	193-350	1.96-4.60
Low electrical resistivity	18.5-27	15-41	-0.5 to -1.6	48-64	1.70-1.73
Near zero stress	14-16	8-24	-0.08-0.06	56-57	1.71-1.72
Good leveling	36-36.5	14-19	2.0	128-137	1.82
Thermal stability ^b	22.5-30	26-39	0.5-2.9	55-106	1.73-1.76

^aNegative values indicate a compressive stress.

^bDeposits that changed less than 0.02% in length after heating to 40°C.

SOLUS-1035, 18

220. Accordingly, Dobashi in view of common and prior knowledge renders obvious this limitation.

(v) Claim 5

[5pre] A current collector for a secondary battery, the current collector comprising:

221. Dobashi describes that “the surface-treated electro-deposited copper foil according to the present invention can also be suitably used as the negative electrode current collector of a lithium ion secondary battery.” SOLUS-1007, [0107].

[5a] the electrolytic copper foil according to claim 1; and

222. See discussion *supra* claim 1.

[5b] a protective layer disposed on the electrolytic copper foil,

[5c] wherein the protective layer comprises at least one of chromate, benzotriazole and a silane compound.

223. Dobashi renders obvious [5b]-[5c]. For example, the '090 Patent describes that the protective layer can be formed when “the electrolytic copper foil” is “subjected to anti-corrosion treatment using chromate, benzotriazole, and/or a silane compound.” See SOLUS-1001, 5:65-67, 6:1-10.

224. Similarly, Dobashi describes “a surface-treated electro-deposited copper foil according to the present invention is a surface-treated electro-deposited copper foil in which any one or more of *rust-proofing treatment* and/or *silane coupling agent treatment are performed on the surface of an electro-deposited copper foil.*” SOLUS-1007, [0011].

225. Accordingly, Dobashi renders obvious this limitation.

226. Alternatively/additionally, for similar reasons with respect to those discussed above regarding Ground 1B (e.g., claim 5, reasons for the combination section), prior art (Toshio or Kim) already renders this limitation obvious and provides sufficient motivation for a POSITA to apply the claimed protective layer onto either untreated copper foil surfaces or treated copper foil surfaces with reasonable expectation of success. See discussion *supra* Part VII. B.

(vi) Claim 6

[6] The current collector according to claim 5, wherein the protective layer is formed on the first and second surfaces of the electrolytic copper foil.

227. Dobashi in view of common and prior knowledge renders obvious this limitation.

228. First, as described above with respect to discussion of claim 5, Dobashi describes applying protective layer(s) to the surface of the electrolytic copper foil.

229. Second, for similar reasons with respect to those discussed above regarding claim 6 in Ground 1B, prior art teaches that [1] active material can be formed on both surfaces of the current collector substrate and [2] protective layer(s) such as an anti-rust layer or a corrosion-proof layer can be applied in between the copper foil surfaces of the current collector and the active material layer. *See discussion supra* Part VII. B.

230. Further, it is my opinion that it would've been obvious for a POSITA to apply the protective layer(s) to both surfaces of the copper foil when aiming to achieve a rust-proof effect between the copper foil surface of the current collector and the active material for electrodes of secondary batteries.

(vii) Claim 7

[7pre] An electrode for a secondary battery, the electrode comprising:

231. *See discussion supra* section [1pre].

[7a] a current collector comprising the electrolytic copper foil according to claim 1; and

232. Dobashi describes that “the surface-treated electro-deposited copper foil according to the present invention can also be suitably used as the negative electrode current collector of a lithium ion secondary battery.” SOLUS-1007, [0107].

[7b] an active material layer disposed on the current collector;

233. Although this limitation is not explicitly disclosed Dobashi, this is an inherent and otherwise obvious feature that would have been well-known by a POSITA in the field. It was common knowledge that the active material or active material layer is disposed on the current collector and that the active material layer is essential for the functioning of the secondary battery, for example, for the operation of the battery's electrochemical reactions during charging and discharging processes.

234. Further, as described above with respect to claim limitation [7b] of Ground 1, prior art (Shinozaki) confirms the prior and common knowledge relating to the active material layer being disposed on the current collector. SOLUS-1004, [0038]; *see generally id.*, [0003]-[0026].

235. Accordingly, Dobashi in view of common and prior knowledge renders obvious this limitation.

[7c] wherein the active material layer comprises at least one active material selected from the group consisting of: carbon; a metal (Me) of Si, Ge, Sn, Li, Zn, Mg, Cd, Ce, Ni or Fe; an alloy containing the metal; an oxide of the metal (MeOx); and a chemical compound of the metal and carbon.

236. As described above with respect to discussion of [7b], it was common knowledge that the active material or active material layer is essential for functioning of the secondary battery, for example, for operation of a battery's electrochemical reactions during charging and discharging processes.

237. Further, it was already disclosed that silicon, germanium, tin, or an alloyed compound thereof could be used as one or more of the active materials. SOLUS-1004, [0038] (“The electrolytic copper foil for lithium ion secondary battery is used as the collector, and the active material which is deposited on its surface is comprised of primary particles of silicon, germanium, or tin or an alloyed compound of the same or of secondary particles which are obtained by processing the primary particles”).

238. Accordingly, Dobashi in view of common and prior knowledge renders obvious this limitation.

(viii) Claim 8

[8] The electrode according to claim 7, wherein the active material layer comprises Si.

239. As described above with respect to discussion of [7c], it was already disclosed that silicon can be used as an active material layer. SOLUS-1004, [0038]

(ix) Claim 9

[9] The electrode according to claim 7, wherein the current collector further comprises a protective layer comprising at least one of chromate, benzotriazole and a silane compound, and wherein the protective layer is interposed between the electrolytic copper foil and the active material layer.

240. Dobashi in view of common and prior knowledge renders obvious this limitation.

241. First, as described above with respect to discussion of claim 5, Dobashi describes applying protective layer(s) to the surface of the electrolytic copper foil.

242. Second, for similar reasons with respect to those discussed above regarding claim 6 in Ground 1B, prior art teaches that [1] active material can be formed on both surfaces of the current collector substrate and [2] protective layer(s) such as an anti-rust layer or a corrosion-proof layer can be applied in between the copper foil surfaces of the current collector and the active material layer. *See discussion supra* Part VII. B.

243. Alternatively/additionally, for similar reasons with respect to those discussed above regarding Ground 1B (e.g., claim 9, reasons for the combination section), prior art (Toshio or Kim) already renders this limitation obvious and provides sufficient motivation for a POSITA to apply the claimed protective layer onto either an untreated copper foil surface or a treated copper foil surface before applying the active material layer. *See id.*

(x) Claim 10

[10pre] A secondary battery comprising:

244. *See* discussion *supra* claim 1, 7.

[10a] a cathode; an anode; an electrolyte for providing an environment enabling lithium ions to move between the cathode and the anode; and a separator for electrically insulating the cathode from the anode,

245. This limitation relates to conventional knowledge.

246. For example, as explained in prior art, it was conventional [1] for a battery to have both a cathode, and an anode, and an electrolyte, [2] that the electrolyte is “for providing an environment enabling lithium ions to move between the cathode and the anode” and [3] the secondary battery would have a separator for electrically insulating the cathode from the anode. SOLUS-1012, [0006] (“A lithium secondary battery generally includes a cathode and an anode, which are arranged with a separator being interposed between them, and an electrolyte”).

[10b] wherein the anode comprises: a current collector comprising the electrolytic copper foil according to claim 1; and

247. *See* discussion *supra* claim 1, 7.

[10c] an active material layer disposed on the current collector.

248. *See* discussion *supra* claim 7.

(xi) Claim 11

[11] The secondary battery according to claim 10, further comprising a protective layer comprising at least one of chromate, benzotriazole and a silane compound, wherein the protective layer is interposed between the electrolytic copper foil and the active material layer.

249. See discussion *supra* claim 5, 6, 9.

VIII. LEGAL PRINCIPLES

A. Anticipation

250. I have been informed that a patent claim is invalid as anticipated under 35 U.S.C. § 102 if each and every element of a claim, as properly construed, is found either explicitly or inherently in a single prior art reference. Under the principles of inherency, if the prior art necessarily functions in accordance with, or includes the claimed limitations, it anticipates.

B. Obviousness

251. I have been informed that a patent claim is invalid as “obvious” under 35 U.S.C. § 103 in light of one or more prior art references if it would have been obvious to a POSITA, taking into account (1) the scope and content of the prior art, (2) the differences between the prior art and the claims, (3) the level of ordinary skill in the art, and (4) any so called “secondary considerations” of non-obviousness, which include: (i) “long felt need” for the claimed invention, (ii) commercial success attributable to the claimed invention, (iii) unexpected results of the claimed invention, and (iv) “copying” of the claimed invention by others.

252. I have been informed that a claim can be obvious in light of a single prior art reference or multiple prior art references. To be obvious in light of a single prior art reference or multiple prior art references, there must be a reason to modify the single prior art reference, or combine two or more references, in order

to achieve the claimed invention. This reason may come from a teaching, suggestion, or motivation to combine, or may come from the reference or references themselves, the knowledge or “common sense” of one skilled in the art, or from the nature of the problem to be solved, and may be explicit or implicit from the prior art as a whole. I have been informed that the combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results. I also understand it is improper to rely on hindsight in making the obviousness determination.

IX. CONCLUSION

253. I currently hold the opinions set expressed in this declaration. But my analysis may continue, and I may acquire additional information and/or attain supplemental insights that may result in added observations.

254. I declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both under Section 1001 of Title 18 of the United States Code.

Dated: September 19, 2024 By: Thick Salt 9/19/2024

APPENDIX A

Michael S. Randall

313 River Walk Drive
Simpsonville, SC 29681
Phone: 864-608-1047
Almegacy@gmail.com

SUMMARY: Seasoned technologist, inventor, subject matter expert, entrepreneur and economic development specialist with over 30 years of experience in R&D, product development, intellectual property, and business identification including design, materials, processing, analysis, testing and business development, having a record of taking ideas to profitable products. An experienced consultant having provided expert services in the areas of electronic materials, components and assemblies, intellectual property, product development, process optimization, market studies, and grants. Recognized technical expert in electronic components and certified Six Sigma Black Belt (DFSS). Award winning author, inventor, board member, subject matter expert, lecturer, adjunct professor, entrepreneur and technical consultant.

WORK EXPERIENCE:

9/03 to present	Almegacy LLC, President & CEO Consulting
10/08 to 1/17	Health Sciences South Carolina, Chief Economic Development Officer
11/99 to 8/08	KEMET Electronics, Director Advanced Technology
10/97 to 11/99	Ferro Corporation, Ferro Electronic Materials Division, Director of Research and Development
10/92 to 10/97	AVX Corporation, Advanced Products and Technology Center, Manager of Ceramic Capacitor Research and Development
3/97 to 10/97	Webster University, Myrtle Beach Metropolitan Campus, Adjunct Professor
12/91 to 10/92	Engineering Consulting Firm of Gould, Lewis, and Proctor, Engineering Consultant
5/85 to 12/91	University of Florida, Graduate Research Associate
7/83 to 1/84	National Bureau of Standards (NIST), Research Engineer (Cooperative Education Program with Alfred University)

EDUCATION:

Aug 1993	PhD Materials Science and Engineering, University of Florida (GPA: 3.96/4.00)
May 1985	MBA Business Management, Webster University (GPA: 4.00/4.00)
Aug 1987	MS Materials Science and Engineering, University of Florida (GPA: 3.95/4.00)
May 1985	BS Ceramic Engineering, NYSCC at Alfred University, Minors in Chemistry and Business Management (GPA: 3.85/4.00) magna cum laude

SPECIALIZED EXPERIENCE:

Electronic Materials and Processing, Ceramic Dielectric Materials, Processing and Analysis, Electronic Components and Assemblies, Surface Mount Technology, Invention and Ideation, Reliability Assessment, New Product Development, Business Development, Economic Development, Subject Matter Expert Witness and Support, Grants, Intellectual Property, Product Liability Technology Leader's Forum, DFSS/6 σ Black Belt, Leadership, TOPS, DOE, QOS, FMEA

PROFESSIONAL TRAINING:

AWARDS:

KEMET (Club of Excellence, ELT, Best & Brightest), InnoVision Winner and Runner Up, Best Paper, Distinguished Writer, Outstanding Student, Scholarship

SOCIETIES:

AcerS, SMTA, IMAPS, MRS, AESF, A Σ M, TBPI, Φ K Φ , $\Delta\Delta\Delta$

PUBLICATIONS/PRESENTATIONS:

More than 100, More than 20 Invited, 2 Best Paper awards

SUBJECT MATTER EXPERT:

Multiple cases (patents, NDAs, product liability (ITC, PTAB, District Courts, etc.))

PATENTS:

20 U.S. Patents Granted, 2 Chinese

GRANTS:

Managed DARPA grant, assisted NIH GO Grant, ARRA/ONC HITECH Grant, ARPA-eBEEST Program award, The Duke Endowment, SC-Israel Collaborative (>\$25M in grants total)

SESSION CHAIR/LECTURER:

5 Symposia, multiple lectures at undergraduate and graduate levels

PERSONAL:

US Citizen with active passport, married, 2 children

August, 2024

WORK EXPERIENCE:

9/03 to Present Almegacy LLC, Simpsonville, SC
President, Consulting

- Provides ideation, invention, selection, sourcing, design, materials, processing, analysis, technology, IP and expert services, as well as equipment selection for electronic components
 - Electronic device, assemblies and related materials consulting including design, formulation, processing and testing development
 - Electronic component design, characterization, selection, assembly and sourcing for projects (active and passive)
 - Capacitors (SLC, MLCC, GBLC, Film, Ta, AE, EDLC/Supercapacitors, Hybrid/Pseudocapacitors, others), resistors (thick and thin film), inductors and terminators, antennae, batteries (primary and secondary), oscillators, LEDs, integrated Circuits, microprocessors, transducers, power harvesters and sensors (mechanical and gas including smart sensors), thermoelectric devices, and other passive electronic components and chassis/hardware
 - Component performance and reliability assessment and modeling
 - Adhesive/coating/potting/encapsulation selection
 - Selection and management of PCB fabrication and assembly processes
 - Advisement on product compliance per specification, including RoHS and REACH
 - Electronic materials selection and sourcing including ceramics, metals, and organics
 - Device, materials, process development and analysis for materials and related electronic components
 - High temperature materials selection, evaluation, design and processing
 - High energy density storage materials and devices design and development assistance
 - Product development assistance including design, materials selection and sourcing, processing and related process equipment, test and analysis, packaging, intellectual property protection and marketing
- Technical marketing studies for emerging proprietary technologies, including devices, materials, test and measurement, and associated equipment, intellectual property and technologies
- Consulted on ARPA-e grant team BEEST Program Award Recapping, Inc.: High Energy Density Capacitors, program in coordination with Recapping (Khosla Ventures funded) and Pennsylvania State University
- Subject matter expert:
 - Expert support for USPTO PTAB ex partes reexaminations, inter partes reviews, post grant reviews, petitions, responses and other matters regarding patents:

▪ US 6,014,309	▪ US 6,661,639	▪ US 7,307,829
▪ US 6,144,547	▪ US 6,816,356	▪ US 8,536,496
▪ US 6,243,254	▪ US 6,992,879	▪ US 9,326,381
▪ US 6,266,229	▪ US 7,190,252	▪ US 9,475,086
▪ US 6,337,791	▪ US 7,361,869	▪ US 9,798,968
▪ US 6,377,439	▪ US 7,705,776	
 - Expert support for U.S. District Court for the Central District of California, case number 8:09-cv-01124, Murata Manufacturing Co Ltd. v. Samsung Electro Mechanics Co. Ltd., et al., Assisted successful defense against infringement claims regarding US Patents 6,014,309 6,243,254 6,266,229 6,377,439
 - Expert for ITC trial Investigation Number 337-TA-692, “In the Matter of Certain Ceramic Capacitors and Products Containing Same”, Murata v SEMCO. Assisted successful defense against infringement claims regarding US Patents 6,014,309 6,243,254 6,266,229 6,377,439
 - Expert support for ITC trial Investigation Number 337-TA-813, “Certain Electronic Devices With Graphics Data Processing Systems, Components Thereof, and Associated Software”, S3 Graphics v Apple. Assisted successful defense settlement against infringement claims regarding US Patent 5,581,279
 - Expert support for U.S. District Court for the Eastern District of Texas, case number 2:11-cv-00052, MicroUnity Systems Engineering, Inc. v. Apple, Inc., et al. Assisted successful defense settlement against infringement claims regarding US Patent 6,643,765

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- Expert support for U.S. District Court for the Southern District of California, case number 3:14-cv-02061, Presidio Components, Inc. v. American Technical Ceramics Corp., Assisted successful prosecution of infringement on claims regarding US Patent 6,816,356
- Expert for U.S. District Court for the Eastern District of New York, case number 2:14-cv-06544, American Technical Ceramics Corp., and AVX Corporation vs. Presidio Components, Inc. regarding US Patents 6,144,547, 6,337,791, and 6,992,879
- Expert support for Cap-XX Ltd. vs. Maxwell Technologies, Inc., Case No. 19-1733 (CFC), US District Court, District of Delaware, regarding US Patents 6,920,034 and 7,382,600
- Expert support for Envirodigm, Inc. vs. Apple, Inc., Case No. 20CV373138, Superior Court of the State of California for the County of Santa Clara, including successful defense (summary judgement)
- Expert for Fourth Circuit Court, Duval County Florida, product liability case number 16-2010-CA-001815, Gentleman v Medtronic. Assisted successful settlement for client
- Technical and market development advisor to several startup businesses in the field of passive electronic components (high temperature, high energy density storage devices and materials, high temperature gas sensing systems, supercapacitors, hybrid supercapacitors, secondary batteries, including technical and strategic support for US patent 10,679,799)
- Instructor, seminar on patent portfolios and intellectual property at CARTS USA 2011
- Invited instructor, seminar on intellectual property at SmartState™ Council of Endowed Chairs, May 2013
- Invited speaker for ASM seminar (2014-2024)
- Invited lecturer for BioE 8600, Introduction to Common Machining/Manufacturing Techniques for Medical Devices, Good Manufacturing Practices, (October 2014)
- Invited lecturer for BioE 8600, "Manufacturing Technology for Implantable Electronic Medical Devices: Processes, Verification, Validation and Scale-up," November 2016
- Invited lecturer for BioE 8600, "Manufacturing Technology for Implantable Electronic Medical Devices: Processes, Verification, Validation and Scale-up," November 2018
- Invited lecturer for BioE 8600, "Manufacturing Technology for Implantable Electronic Medical Devices: Processes, Verification, Validation and Scale-up," November 2019
- Adjunct professor in Bioengineering, Clemson University
- Technical writer for Venkel, Ltd., technical reports and technical blog "The Circuit: A Blog for Engineers," (subject matter including capacitors, resistors, inductors, LEDs, etc.)
- Marketed IP rights to patent portfolio for emerging technology company
- Client base includes more than 40 clients, from "start up" to "Fortune 100"

10/08 to 1/17 Health Sciences South Carolina, Columbia SC

Chief Economic Development Officer

- Assisted economic and business development at HSSC and 12 sponsored Centers of Economic Excellence
- Intellectual property development, 7 Idea disclosures/applications, 2 US Patents granted, 1 technology license
- New Product Design, Development and New Business Development
- Strategic planning
- Selection and implementation of advanced, HSSC-wide, clinical analytics system
- Promoted networking between member organizations and external organizations to provide business, legal, information and government services needed by member organizations
- Assisted organizations in finding and developing relationships with allied organizations
- Assisted establishment of businesses in South Carolina, promoting quality job creation in South Carolina
- Team member of an ARRA Grand Opportunities ("GO") Grant (RFA OD 09-004. CFDA 93.701) to establish unique Research Permissions Management System, \$4.3M award
- Team member of an ARRA/ONC RC HITECH RC Grant (EP-HIT-09-003) to establish CITIA-SC, \$6.4M award
- Team member for The Duke Endowment Grant II to HSSC, \$11.25M award
- Team member for SC-Israel Collaborative Industry R&D Program Grant, \$1M Total budget

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- Member of the Board of Directors, NXT Health
- Member of the Economic Advisory Board and the Board of Directors of Clemson University Department of Bioengineering
- Established EDAC (Economic Development Advisory Committee) for HSSC membership
- Established Vendor Selection Committee for CITIA-SC (South Carolina's REC) and managed and performed contract review and negotiations for EHR vendor and Analytics Software vendor selection activities
- Assisted development of statewide clinical trials and research system plan
- Established HEAL SC (Health Economy Advancement Legacy for South Carolina) symposium, South Carolina's first statewide health sciences related economic development summit
- Organized SC Collaborative at BIO International
- Represented HSSC at numerous meetings as a Panelist, Panel Leader or Information Conveyor

1/05 to 8/08 KEMET Electronics, Advanced Technology Group, Simpsonville, SC
Director, Advanced Technology

- Business identification, demand creation, invention and NPD for 7 new advanced products from ideation to pilot scale addressing more than \$450M in potential markets
 - D-Stick (low inductance feed through decoupling capacitor)
 - Controlled ESR D-Stick
 - D-Pack (ultra-low inductance feed through capacitor array)
 - L-CAP (low cost, two terminal low inductance capacitor)
 - Controlled ESR L-CAP
 - K-SIP (decoupling capacitor array interposer for SIP packaging)
 - V-Max (very high capacitance density hybrid (anodized Ta/BT sol-gel) dielectric capacitor system)
- Development of non-destructive screening method for enhancement of device reliability
- Intellectual property generation and searches for patentability and product clearance Internal expert for Ceramic Business Group NPD activities
- Technology assessment for due diligence for M&A efforts resulting in successful acquisition of Evox Rifa Oy
- Enhancement of customer relations through specialized designs and prototype evaluations
- Partnering and open innovation activities with customers, suppliers, universities, and government agencies
- Member of Extended Leadership Team (ELT)
- Member of the Club of Excellence (2007 and 2008)
- KEMET Special Recognition Award
- KEMET patent awards: More than 10 U.S. Patents granted U.S.
- Honorable mention in 10 press releases

4/03 to 1/05 KEMET Electronics, Technical Marketing and New Business Dev., Simpsonville, SC
Director of Ceramic Technical Marketing and New Business Development

- Quantification of \$17B Capacitor Market Landscape
- Identification of \$400M+ potential KEMET markets
- Produced and managed Advanced Products Portfolio
- Member of due diligence teams for 9 separate, investment/M and A opportunities
- Established business case and business risk assessment system
- Assisted Development of 4 new product lines
 - HV Commercial SMD MLCC
 - HV Leaded MLCC
 - Flex Robust MLCC
 - Open Mode, Soft Termination, Clip On Leadframe
 - Environmentally friendly, high CV COG MLCC

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- Directed and managed technical support for all ceramic products
- Established highly effective system for competitor analyses/competitive intelligence

11/99 to 4/03 KEMET Electronics, Ceramic Technology, Ft Inn, SC

Director of Ceramic Technology

- Responsible for the direction of seven, process specific, functional teams, providing technology solutions for Multilayer Ceramic Capacitor (MLCC) development needs, including:
 - Mixing, Milling and Coating of Dielectric Tapes
 - Electrode Materials
 - Green Chip Processing
 - Thermal Processing and Corner Rounding
 - Termination Materials and Processing
 - Plating
 - Test and Failure Analysis
- Directed/Assisted Platform product development teams
 - COG, X5R and Y5V (PME and BME)
- Directed/Assisted non-platform development teams
 - Product performance improvement
 - Quality improvement
 - Cost and yield improvement
 - Employee and laboratory performance improvement
- KEMET university liaison for Ceramic Technology Department
- Directed or assisted/facilitated projects responsible for ~70% of ceramic capacitor new product sales

9/98 to 11/99 Ferro Corporation, Ferro Electronic Materials, CA (Formerly The Electronic Materials Division), San Marcos and Santa Barbara, CA

Director of Research and Development

- Responsible for planning, direction and oversight of all division level research and development and new product development, including the following product lines:
 - LTCC (Low Temperature Cofired Ceramic systems)
 - MMS (Multilayer Materials Systems)
 - OEM (Organic Electronic Materials systems)
 - PVS (Photovoltaic materials Systems)
 - RMS (Resistor Materials Systems)
 - TFS (Thick Film materials Systems)
- Directed new product development of more than 225 new line item products accounting for ~25% of FEM, CA FY99 total sales
- Established and managed an R&D/NPD group
- Established a comprehensive R&D information system
- Established and managed a process engineering group
- Established and managed a QA group
- Corporate level R&D interaction for division
- Division level interaction with external product development sources
- Managed divisional intellectual property
- Managed DARPA grant for high aspect ratio electrode printing on low loss dielectric packaging
- Member of Senior Management Committee

10/97 to 9/98 Ferro Corporation, Electronic Materials Division, San Marcos/Santa Barbara, CA**Manager of Research and Development**

- Responsible for planning, management and oversight of all division level research and development and new product development including the product lines outlined above
- Managed new product development of more than 125 new line item products
- Responsible for all corporate level R&D interaction with division
- Established R&D new product development system
- Established R&D long term project portfolio

4/94 to 10/97 AVX Corporation, Advanced Products and Technology Center, Myrtle Beach, SC**Manager of Ceramic Capacitor Research and Development**

- Responsible for planning and oversight of all multi-layered ceramic capacitor development
- Oversight of development of base metal, relaxor and conventional MLCC systems, high CV, low cost (Ni-metallurgy X7R and Y5V, Relaxor-based Y5V/Y5U)
 - For high frequency applications (Cu-metallurgy COG)
 - For harsh environments (X8R/other under-the-hood applications)
 - Assisted Integrated Passive Component development
- Member of AVX Development Council
- Member of AVX Dielectric Strategy Committee
- Oversight Committee for competitor benchmarking
- Interface and assist corporate MLCC development at satellite plants (Myrtle Beach, SC, Conway, SC, Raleigh, NC, Olean, NY, Vancouver, WA, Coleraine, Ireland, Kyocera (Japan and USA))
- Member of Environmental, Health and Safety Council
- AVX Representative to the American Ceramic Industries Association

10/92 to 4/94 AVX Corporation, Corporate Research Laboratory, Conway, SC**Principal Engineer**

- Responsible for pilot scale actuator green fabrication and thermal processing
- Project leader for piezoelectric voltage generator development
- Project leader for voided piezoelectric sensor project
- Developed various piezoelectric and electrostrictive devices

3/97 to 10/97 Webster University, Myrtle Beach Metropolitan Campus, Myrtle Beach, SC**Adjunct Professor** (part time (weekends) while working at AVX)

- Instructor for BUSN 6080: Management Information Systems
- Instructor for BUSN 6150: Business Communications and Technology
- Assisted establishment of computer/communications lab for new, state-of-the-art campus (LAN, ISP, presentation system, etc.)

12/91 to 10/92 The Engineering Consulting Firm of Gould, Lewis and Proctor, Gainesville, FL**Engineering Consultant**

- Designed, built and maintained a direct tension, multi-station, hydraulic apparatus for investigation of and characterization of accelerated stress corrosion cracking and hydrogen embrittlement of high strength steel reinforcement wire used in pre-stressed concrete pipe.
 - Equipment payback achieved within 2 months of implementation. System proved highly reliable and highly profitable.
 - Received a bonus and a raise as reward for the uniqueness, functionality and profitability of the direct tension mechanical test system

5/85 to 12/91 University of Florida, Gainesville, FL**Graduate Research Assistant**

- Performed graduate level research in the areas of phase separation and crystallization in heavy metal fluoride glasses (Master's research) and in the area of low dielectric loss electronic packaging materials (Doctoral research)
- Designed and outfitted a general purpose research laboratory

7/83 to 1/84 National Bureau of Standards (now NIST), Gaithersburg, MD**Research Engineer** (Cooperative Education Program with Alfred University)

- Characterized the high TiO_2 end of the BaO/TiO_2 binary phase diagram via XRD on samples prepared via a drop-tube quench furnace
- Characterized the high Li_2O end of the $\text{Li}_2\text{O/Al}_2\text{O}_3$ binary phase diagram via XRD on samples heat treated in controlled atmosphere or microtorr furnaces
- Rebuilt/redesigned intermediate temperature, microtorr vacuum furnace
- Investigated PSZ/SiC(w) composite precursor powder-whiskers, produced via spray drying, using optical microscopy, SEM, ASEM, and LS particle size analysis
- Assisted set up of a powder processing/characterization laboratory

EDUCATION:**University of Florida, Gainesville, FL****Degree:** Ph.D. Materials Science and Engineering, August 1993**GPA:** 3.96/4.00**Dissertation:** Processing, Characterization and Modeling of Low Dielectric Constant, Low Dielectric Loss, Porous Composites for Use in High Frequency Applications**Candidacy Defense:** "SSACTECD: Smart-Switched, Actively Controlled Transmissive, Electrochromic Device"**Advisors:** Prof. J. H. Simmons, Prof. M. D. Sacks**Webster University, St. Louis, MO (Myrtle Beach, SC Campus)****Degree:** M.B.A. Business Management, May, 1995**GPA:** 4.00/4.00**Thesis:** Case Study: Kyocera Corporation**University of Florida, Gainesville, FL****Degree:** M.S. Materials Science and Engineering, August, 1987**GPA:** 3.95/4.00**Thesis:** Immiscibility and Crystallization in the Cadmium-Lithium-Aluminum-Lead Fluoride Glass System**Advisor:** Prof. J. H. Simmons**N.Y.S. College of Ceramics at Alfred University, Alfred, NY****Degree:** B.S. Ceramic Engineering, May, 1985**Minors:** Chemistry, Business Management**GPA:** 3.85/4.00, Magna Cum Laude**Thesis:** Characterization of PTCR Behavior in BaTiO_3 -Based Thermistors**Advisor:** Prof. V. R. W. Amarakoon

SPECIALIZED EXPERIENCE:

- Ideation and Invention: Inventor on more than 20 patents. Brainstorming Sessions, Options Selection and Projects Portfolio Establishment and Management
- Basic Design and Performance Modeling: Passive Electronic Components and Assemblies: Multilayer Devices (MLCC, Multilayer Arrays, Low ESL MLCC, Controlled ESR MLCC, Multilayer Piezo Devices, Film Capacitors, Electrolytic Capacitors, EDLC/Supercapacitors, Hybrid/Pseudocapacitors), Batteries, LEDs, Thick Film Devices, EMI Filters, LTCC
- Formulation: Dielectrics, Glasses, Thick Film Pastes, Organic Vehicles, Additives and Modifiers
- Synthesis: Ceramic (Barium Titanate, BCT, BCTZ, Calcium Titanate, Calcium Zirconate, PMN/PT, PZT, Glass), Organic (Uniform Polystyrene Latex Particles, Polymethylmethacrylate)
- Powder Processing and Characterization: Batching, Milling, Mixing, Dispersing, Classifying, Coating/Pressing, Surface Area, Particle Size Analyses, Microscopy, Bulk Chemistry, Surface Chemistry, Density (Tap, Pycnometer, Bulk), Porosity (Archimedes, Hg Porosimetry), X-Ray Diffraction, FTIR, ICP, Rheometry (Liquid Viscometry), Fraction Solids (Organic and Ceramic), Other
- Microscopy, Metrology, and Associated Analytical Techniques: Physical, Electrical, Optical, ASEM, ATEM, sample preparation techniques, analysis, and data interpretation
- Analytical Testing Techniques: ICP, LAMS, XRF, XRD, SAED, TGA/DTA, DSC, TMA
- Additive and subtractive manufacturing
- Thermal Processing: Low and High Temperature, Controlled Atmospheres (Vacuum, Inert and Reactive Atmospheres), Microwave Sintering
- Finishing: Corner Rounding, Thick Film Conductors, Plating (Electroless and Electrolytic), Anodizing
- Device Sorting, Testing and Packaging: Capacitance, Dissipation Factor, Dielectric Constant, Dielectric Withstanding Voltage, Dielectric Breakdown Strength, Insulation Resistance, Temperature Coefficient of Capacitance, Field Effect, Dielectric Aging, Tape and Reel, Other
- Battery analysis: ΔT vs. charge/discharge current, capacity vs. temperature, life cycle degradation, ESR, etc.
- Reliability Testing: Thermal Shock, Thermal Cycling, Highly Accelerated Life Test, Life Test, Temperature Humidity Bias Test, Non Destructive Test (CSAM and SLAM), Other
- Analysis and Failure Analysis
- Guidance of product performance vs. specification (Military, Aerospace, Automotive, other)
- Management of board builds including working with PWB fabricators and assemblers, conformal coating selection and RoHS advisement
- Mechanical Characterization: Tension, Torsion, Flexural, Wrap, Pull, and Microhardness/Nanohardness Indentation, Fatigue Acceleration, Lamination/Bond Strength
- Technology Management/Direction: Personnel/Group Management, Project Management, Technology Management, Strategic Analysis, Portfolio Management, Acquisition Analysis and Due Diligence, IP and IP Portfolio Management, Quality Management
- Market Analysis and Business Identification: Electronic Market Segments Analysis, Competitive Intelligence/Analysis, Product Portfolio Management, Roadmap Establishment and Management, Economic Analysis
- Ideation, Technical Author, Statistical Analysis, Lean Design, Design for Manufacturability, Process Design, Grant Writing, Grant Budgeting and Management,
- Subject Matter Expert: Expertise in Electronic Components such as Multilayer Capacitors, Resistors, Inductors, Batteries, LEDs, as well as Surface Mount Technology, Electronic Assemblies, and Related Design, Materials, Processing, Testing and Markets

PROFESSIONAL TRAINING AND CERTIFICATIONS:

- Team Oriented Problem Solving (TOPS II/TOPS III, Global 8D, Ford Sanctioned)
- Design of Experiments (DoE, StorageTek, KEMET, Minitab Sanctioned)
- Failure Modes and Effects Analysis (FMEA, Ford Sanctioned)

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- QV2000/Quality Operating System (QOS, AVX Sanctioned)
- A Leadership Course In: Effective Employee Motivation (Dun and Bradstreet)
- A Leadership Course in: Effective Time Management (Dun and Bradstreet)
- Making Managers Into Leaders (Enlightened Leadership International)
- Project Management Training (CareerTrack)
- Managing Multiple Projects and Priorities (Fred Pryor)
- The Seven Habits of Highly Successful People (Stephen Covey, Fred Prior Sanctioned)
- Personal Productivity (The Leadership Group Sanctioned)
- Effective Leadership Skills (The Leadership Group Sanctioned)
- Project Planning with Microsoft Project (Sam Brooks Associates, Microsoft sanctioned)
- Benchmarking: An Introduction (AVX sanctioned)
- Technology Forum (KEMET Sanctioned)
- Lean Six Sigma, Design for Six Sigma (Green Belt and Black Belt Trained and Certified)
- KEMET Technology Leadership Forums

AWARDS:

- Member, KEMET ELT (Extended Leadership Team, 2005-2008)
- Member, KEMET Club of Excellence 2007, 2008
- Noted as one of KEMET's Best and Brightest (KEM press release, December 19, 2006)
- Innovision Awards Finalist (D-Pack), 2006
- Innovision Awards Winner (Green BME COG), 2007
- KEMET Special Recognition Award, 2008
- KEMET Patent Awards, 2006, 2007, 2008
- John D. Moynihan Best Paper Award, CARTS USA 2003
- Distinguished Writer Award, AVX Corporation, Recipient (1995, 1996, 1997)
- University of Florida President's Recognition for Outstanding Students (1992)
- University of Florida Graduate Council Fellowship, Recipient (1985-1986)
- Alfred University Southern Tier Scholarship, Recipient (1981-1985)
- New York State Regents Scholarship, Recipient (1981-1985)

SOCIETIES:

ACerS Reviewer for Journal of the American Ceramic Society, 2011-Present, Director of History and Personnel, Electronics Division 2005, ACerS Director of Corporate Membership, Electronics Division 2006, ACIA Board Member, Session Chair, Committee Chair for Electronic Division History and Personnel Committee, ACerS (technical reader for Ceramic Transactions 19: Advanced Composite Materials 1988), Keramos (University of Florida Secondary Founder, Secretary, Treasurer 1986), MRS, ISHM/IMAPS (founded the University of Florida Chapter 1986, Board Member of So Cal IMAPS, Editor of So Cal IMAPS Newsletter 1997), SMTA, AESF, IEEE, Alpha Sigma Mu, Tau Beta Pi, Phi Kappa Phi, Alpha Lambda Delta

SELECT PUBLICATIONS, LECTURES, POSTERS AND PRESENTATIONS:

- M. Randall, "Anodizing," ASM International, Greenville Old South Chapter, February 2024
- M. Randall, "Thoughts and Considerations on Crossing MLCCs," Venkel Ltd., White Paper, November, 2022
- M. Randall, "Manufacturing Technology for Implantable Electronic Medical Devices: Processes, Verification, Validation and Scale-up," invited lecture, Clemson University Department of Bioengineering, BioE 8600: Biomedical Engineering Device Design Innovation, November 6, 2020
- M. Randall, "Ceramic Capacitors: The Smart Replacement for Electrolytic Capacitors," Venkel Ltd., Technical Paper, September 2020.
- M. Randall, "More About Circuits," article for Venkel technical blog, March, 2020.

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- M. Randall, "AC Series and Parallel Circuits: Inductors and Capacitors," article for Venkel technical blog, March, 2020.
- M. Randall, "Series and Parallel Circuits 3: Capacitors" article for Venkel technical blog, March, 2020.
- M. Randall, "Series and Parallel Circuits 2: Resistors," article for Venkel technical blog, March, 2020.
- M. Randall, "Series and Parallel Circuits 1: The Basics," article for Venkel technical blog, March, 2020.
- M. Randall, "LEDs: Data Sheets, Drivers and More Applications," article for Venkel technical blog, March, 2020.
- M. Randall, "Manufacturing Technology for Implantable Electronic Medical Devices: Processes, Verification, Validation and Scale-up," invited lecture, Clemson University Department of Bioengineering, BioE 8600: Biomedical Engineering Device Design Innovation, November 1, 2019
- M. Randall, "Materials Analysis: Examples Used in IP Litigation," invited talk ASM Greenville SC, January 10, 2019.
- M. Randall, "Manufacturing Technology for Implantable Electronic Medical Devices: Processes, Verification, Validation and Scale-up," invited lecture, Clemson University Department of Bioengineering, BioE 8600: Biomedical Engineering Device Design Innovation, November 9, 2018.
- M. Randall, "MELF Resistors: Applications," article for Venkel technical blog, August 2018.
- M. Randall, "MELF Resistors: Performance," article for Venkel technical blog, July 2018.
- M. Randall, "Welcome Back! MELF Resistors," article for Venkel technical blog, July 2018.
- M. Randall, "LED Applications," article for Venkel technical blog, August 2017.
- M. Randall, "Optical Properties of LEDs," article for Venkel technical blog, August 2017.
- M. Randall, "LEDs: How they are made," article for Venkel technical blog, July 2017.
- M. Randall, "A Brief Introduction to High Voltage Surface mount Capacitors," Venkel Ltd., Technical Paper, March 2017.
- M. Randall, "This Little Light of Mine: LED Basics," article for Venkel technical blog, March 2017.
- M. Randall, "Manufacturing Technology for Implantable Electronic Medical Devices: Processes, Verification, Validation and Scale-up," invited lecture, Clemson University Department of Bioengineering, BioE 8600: Biomedical Engineering Device Design Innovation, November 18, 2016.
- M. Randall, "Surface Mount Power Inductors," article for Venkel technical blog, December 2015.
- M. Randall, "The Definitive Guide to Surface Mount Resistor Selection," Venkel Ltd., Technical Paper, November 2015.
- M. Randall, "Part I: Introduction to Common Machining/Manufacturing Techniques for Medical Devices and Good Manufacturing Practices," invited lecture, Clemson University Department of Bioengineering, BioE 8600: Biomedical Engineering Device Design Innovation, October 23, 2015.
- M. Randall, "Chip Components and Surface Mounting," article for Venkel technical blog, February 2015.
- M. Randall, "Tin Whiskers and Chip Components," article for Venkel technical blog, February 2015.
- M. Randall, "SMT Chip Shelf Life: Solderability and IMC Considerations," article for Venkel technical blog, February 2015.
- M. Randall, "Chip Resistor Power Considerations," article for Venkel technical blog, December 2014.
- M. Randall, "Chip Resistors Part 3: Applications and Considerations," article for Venkel technical blog, November 2014.
- M. Randall, "Chip Resistors Part 2: Types," article for Venkel technical blog, October 2014.
- M. Randall, "Chip Resistors Part 1: The Basics," article for Venkel technical blog, October 2014.
- M. Randall, "High Voltage MLCCs: SHOCKING REVELATIONS! Part 3: It Ain't the Volts, It's the Amps: Some Applications and Considerations," article for Venkel technical blog, October 2014.

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- M. Randall, "High Voltage MLCCs: SHOCKING REVELATIONS! Part 2: Judging a Book by Its Cover: Don't Forget the Outside," article for Venkel technical blog, September 2014.
- M. Randall, "High Voltage MLCCs: SHOCKING REVELATIONS! Part 1: It's What's Inside that Counts," article for Venkel technical blog, September 2014.
- M. Randall, "Capacitor ESR: It's EaSiEr than you think!," article for Venkel technical blog, August 2014.
- M. Randall, "Decoupling Part 2: Low ESL MLCCs," article for Venkel technical blog, August 2014.
- M. Randall, "Decoupling Part 1: The Basics," article for Venkel technical blog, July 2014.
- M. Randall, "Class 1 MLCC v. Film Capacitors: And the Winner Is...," article for Venkel technical blog, July 2014.
- M. Randall, "Class 1 Ceramic Capacitors are First Class," article for Venkel technical blog, July 2014.
- M. Randall, "Business Plans," invited lecture, University of South Carolina Arnold School of Public Health, HSPM 791: Healthcare Innovations, June 22, 2015.
- M. Randall, "Deviant Behavior Part 3: Seen and Not Heard," article for Venkel technical blog, June 2014.
- M. Randall, "A Farad on the Head of a Pin for Free," invited talk ASM Greenville SC, October 23, 2014.
- M. Randall, "Deviant Behavior Part 2: Dude, Where's My Capacitance?," article for Venkel technical blog, June 2014.
- M. Randall, "Deviant Behavior Part 1: CRLZ Gone Wild," article for Venkel technical blog, June 2014.
- M. Randall, "A Farad on the Head of a Pin for Free," article for Venkel technical blog, May 2014.
- Invited panelist, Healthcare: IT-Ology Summit on Information Technology, Columbia SC April 23, 2014.
- N. Bailey and M. Randall, "Testing and Measurement Practices of High Capacitance Ceramic Capacitors," Venkel, Ltd., Technical Paper, March 2014.
- Invited panelist (Moderator), Health IT: SCBIO Face to Face, Charleston, SC November 14, 2013.
- M. Randall, "Optimize and Protect Your Patent Portfolio," invited talk, South Carolina SmartState™ Council of Chairs Meeting, Columbia SC, May 15, 2013.
- J. Gasque, M. Randall, W. Harrell, G. Alapatt, "Better Impedance Measurement Using Kelvin-Type Test Fixturing," CARTS International 2012 Proceedings, Las Vegas, NV, pp. 157-185, March, 26-29, 2012.
- M. Randall, "Optimize and Protect Your Patent Portfolio," invited instructor, for-free seminar," CARTS USA 2011, Jacksonville, FL, 9:00am to Noon, March 28–30, 2011.
- M. Randall, "Electronic Health Records: Vendor Selection Process and Next Steps," South Carolina Primary Health Care Association Annual Conference, Invited Talk, Myrtle Beach, SC, October 15-17, 2010.
- M. Randall, "SEMCO MLCC Tutorial Presentation," Trial Investigation Number 337-TA-692, "In the Matter of Certain Ceramic Capacitors and Products Containing Same," Presentation to the Court of the International Trade Commission, Washington D.C., July 21, 2010.
- M. Randall, "CITIA-SC Vendor Selection and Group Purchasing Committee Update," SCORH Rural Health Clinic Meeting, Invited talk, Columbia, SC, June 9, 2010.
- M. Randall, "Vendor Selection and Group Purchasing Committee Update," HIT SC Summit #8, Invited talk, April 22, 2010.
- M. Randall, "A Statewide Clinical Trials System," Invited talk, 2nd Annual South Carolina Human Research Conference, Greenville, SC, November 13, 2009.
- J. Prymak, M. Randall, P. Blais, B. Long, P. Staubli, E. Chen, "Why 47 μ F Capacitor Drops to 37 μ F, 30 μ F, and Lower," CARTS Europe 2008 Proceedings, Helsinki, Finland, October 20-23, 2008.
- J. Prymak, E. Reed, R. Hahn, M. Randall, P. Blais, B. Long, "Decoupling Solutions," CARTS USA 2008 Proceedings, Newport Beach, CA, March 18–20, 2008.
- J. Prymak, M. Randall, P. Blais, B. Long, "Why That 47 μ F Capacitor Drops to 37 μ F, 30 μ F, or Lower," CARTS USA 2008 Proceedings, Newport Beach, CA, March 18–20, 2008.

- J. Prymak, E. Reed, M. Randall, P. Blais, B. Long, "Decoupling Solutions," PCI (Passive Components Industry) Magazine, pp. 8-13, January-February, 2008.
- M. Randall, T. Kinard, J. Qazi, R. Hahn, P. Lessner, A. Tajuddin, S. Troler-McKinstry, S. Ko, T. Dechakupt, C. Randall, E. Dickey, "Hybrid Dielectric," 13th US-Japan Seminar on Dielectric and Piezoelectric Ceramics, pp. 315-18, Hyogo, Japan, November 4-7, 2007.
- M. Randall, J. Prymak, M. Laps, G. Renner, E. Chen, K. Lai, "D-Pack 3D Interposer Decoupling System", CARTS Asia 2007 Proceedings, Taipei, Taiwan, October 9 – 13, 2007.
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- M. Randall, "Precious and Base Metal Powders: Application in the Manufacture of Multilayer Ceramic Capacitors," Invited talk, Clarkson Center for Advanced Materials Processing (CAMP) Meeting, Saratoga Springs, NY, (May 13-15, 2002).
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- M. S. Randall, J. H. Simmons, "Primary and Secondary Phase Separation in Mixed Cadmium Lead Fluoride Glasses," presented at the ACerS Annual Glass Division Meeting, Bedford, PA, (Sept. 30-Oct. 2, 1987).
- More than 25 Technical Posts for Venkel, Ltd. "The Circuit: A Blog for Engineers," covering the subjects of Capacitors, Ceramic Capacitors, High Voltage Capacitors, Decoupling, ESR, Resistors, MELF Resistors, Inductors, Light Emitting Diodes, Tin Whiskers, Surface Mounting of Chip Components, etc.

PATENTS:

- 6,162,849, "Thermally Conductive Thermoplastic," Q. Zhuo, R. M. Harris, D.C. Skovran, L.F. Lightner, M.S. Randall, V. E. Stygar.
- 6,906,907, "Monolithic Multi-Layer Capacitor with Improved Lead-Out Structure," J. D. Prymak, M.S. Randall.
- 7,054,137, "Refractory Metal Nickel Electrodes for Capacitors," D.E. Barber, A. Wang, M.S. Randall, A. Tajuddin.
- 7,211,740, "Valve Metal Electromagnetic Interference Filter," M.S. Randall.
- 7,277,269, "Refractory Metal Nickel Electrodes for Capacitors," D.E. Barber, A. Wang, M.S. Randall, A. Tajuddin.
- 7,280,342, "Low Inductance, High ESR Capacitor," M.S. Randall, A. Hill, P. Blais, G. Renner, R. Vaughan, A. Tajuddin.
- 7,292,429, "Low Inductance Capacitor," M.S. Randall, J. Prymak, A. Tajuddin.

August, 2024

- 7,545,623 and WO2008067300, "Interposer Decoupling Array Having Reduced Electrical Shorts," M. Randall, G. Renner.
- 7,670,981 and CN101456731, "COG multi-layered ceramic capacitor," M.S. Randall, C. Antoniadis, D.E. Barber, X. Xu, J. Beeson, P. Pinceloup, A. Gurav, T. Poole, A. Tajuddin, I. Burn.
- 7,916,451 and CN101456731, "COG multi-layered ceramic capacitor," M.S. Randall, C. Antoniadis, D.E. Barber, X. Xu, J. Beeson, P. Pinceloup, A. Gurav, T. Poole, A. Tajuddin, I. Burn.
- 7,923,395 and CN101456731, "COG multi-layered ceramic capacitor," M.S. Randall, C. Antoniadis, D.E. Barber, X. Xu, J. Beeson, P. Pinceloup, A. Gurav, T. Poole, A. Tajuddin, I. Burn.
- 7,958,627, "Method of attaching an electronic device to an MLCC having a curved surface," M.S. Randall, C. Wayne, J. McConnell.
- 8,111,524 and CN101632173, "Electronic Passive Device," M. Randall, G. Renner, J. Prymak, A. Tajuddin.
- 8,293,323 "Thin Metal Film Conductors and Their Manufacture," S. Troler-McKinstry, C.A. Randall, S.W. Ho, M.S. Randall.
- 8,414,962, "Microcontact Printed Thin Film Capacitors," S. Troler-McKinstry, C.A. Randall, H. Nagata, P. I. Pinceloupe, J.J. Beeson, D.J. Skamser, M.S. Randall, A. Tajuddin.
- 8,717,774, "Electronic Passive Device," M.S. Randall, G. Renner, J.D. Prymak, A. Tajuddin.
- 8,828,480, "Microcontact Printed Thin Film Capacitors," S. Troler-McKinstry, C.A. Randall, H. Nagata, P. I. Pinceloup, J.J. Beeson, D.J. Skamser, M.S. Randall, A. Tajuddin.
- 8,895,940, "Switch Sanitizing Device," J. Moskowitz, M. Randall.
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- 10,231,581, "Touch point area disposable contamination barrier dispensing device," J. Moskowitz, M. Randall.

SESSION CHAIR:

- Workshop Facilitator for the High Volume MLCC Components Session of the Spring 2002 Meeting of the Center for Dielectric Studies, State College, PA, April 23-24, 2002.
- Session Chair for the Microwave and LTCC Materials Session of the 27th Annual Cocoa Beach Conference and Exposition on Advanced Ceramics and Composites, Cocoa Beach, FL, January 26-31, 2003.
- Session Chair for the BME Session of the Spring, 2003 Meeting of the Center for Dielectric Studies, State College, PA, April 24-25, 2003.
- Panel Leader for Face to Face Health Information Technology Breakout Panel, November, 2013.

COMMUNITY SERVICE:

- United Way
 - Executive Director, KEMET Corporate Campaign: Team raised over \$250K, a new record for KEMET
 - Assistant Director, KEMET Corporate Campaign
 - Member Palmetto Society
- CROP WALK
 - Manager for Eastminster Presbyterian Church
 - Team secured Pledges in Excess of \$250K
 - Board Member, CROP Walk Greenville, SC
 - CROPWALK Participant
- Eastminster Presbyterian Church, Elder and Stewardship Committee
 - Team secured ~\$1M in Pledges
- Golden Strip YMCA, Board of Directors, Property Team Director
 - Hollingsworth property development plan and approval
 - Golden Strip YMCA Improvement Plan, author and champion
 - Golden Strip YMCA, Board of Directors
- Habitat for Humanity, Habitat Partner's Council

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- Trees for the Future donor (providing funding to enable the planting of >500,000 trees)
- FLL: First Lego League team captain for Sterling School (Charles Townes Center)
- Junior Achievement Instructor (JA Economics, JA Interpersonal Skills, JA Our World Economics, JA Business Structure, JA Our Cities)
- Blood Donor, 3 Galloneer

PERSONAL:

- Married (Dr. Sara Pittman Elder Randall, Ph.D. Metallurgy, University of Florida, 1990)
- Two children
- U.S. Citizen with active passport

REFERENCES: Available upon request