

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent of: Seung Min Kim, et al.
U.S. Patent No.: 10,811,689 Attorney Docket No. 57533-0002IP1
Issue Date: October 20, 2020
Appl. Serial No.: 15/696,360
Filing Date: September 6, 2017
Title: EASILY HANDLEABLE ELECTROLYTIC COPPER FOIL,
ELECTRODE COMPRISING THE SAME, SECONDARY
BATTERY COMPRISING THE SAME, AND METHOD
FOR MANUFACTURING THE SAME

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**PETITION FOR *INTER PARTES* REVIEW OF UNITED STATES PATENT
NO. 10,811,689 PURSUANT TO 35 U.S.C. §§ 311–319, 37 C.F.R. § 42**

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LIST OF EXHIBITS

- SOLUS-1001 U.S. Patent No. 10,811,689 (“the ’689 Patent”)
- SOLUS-1002 Excerpts from Prosecution History of the ’689 Patent (“the Prosecution History”)
- SOLUS-1003 Declaration of Dr. Michael Randall
- 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 G. Khatibi et al., *Temperature Dependent Elastic and Thermal Properties of Thin Copper Foil*, Copper; Proceedings of the International Conference Copper '06 (2006) (“Khatibi”)
- 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 Reserved
- 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 Reserved
- SOLUS-1027 U.S. Patent No. 10,480,090 (“the ’090 Patent”)
- SOLUS-1028 Japanese Patent Pub. No. 2003/051340A (“Hara”)
- SOLUS-1029 Certified English Translation of JP 2003/051340A and Translator’s Declaration (“Hara”)
- 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 *Thermal Expansion - Linear Expansion Coefficients*, The Engineering ToolBox,
https://www.engineeringtoolbox.com/linear-expansion-coefficients-d_95.html.
- SOLUS-1036 *Linear Thermal Expansion Coefficients of Metals and Alloys*, Laser and Optics User's Manual,
https://psec.uchicago.edu/thermal_coefficients/cte_metals_05517-90143.pdf.
- SOLUS-1037 Reserved
- SOLUS-1038 *SK nexilis Co., Ltd. v. Solus Advanced Materials Co., Ltd. et al.*,

Case 2-23-cv-00539 (EDTX), Proposed Scheduling Order

SOLUS-1039 *SK nexilis Co., Ltd. v. Solus Advanced Materials Co., Ltd. et al.*,

Case 2-23-cv-00539 (EDTX), Motion to Transfer Venue

SOLUS-1040 Declaration of June Ann Munford

CLAIM LISTING

Limitation	Claim Language
[1pre]	An electrolytic copper foil, which includes a first surface and a second surface opposite the first surface, the electrolytic copper foil comprising:
[1a]	a copper layer including a matte surface facing the first surface and a shiny surface facing the second surface;
[1b]	a first protective layer on the matte surface of the copper layer; and
[1c]	a second protective layer on the shiny surface of the copper layer,
[1d]	wherein: a coefficient of thermal expansion of the electrolytic copper foil, which is measured using a thermomechanical analyzer (TMA) while heating the electrolytic copper foil from 30° C. to 190° C. at a speed of 5° C./min, ranges from 16 to 22 $\mu\text{m}/(\text{m}\cdot^{\circ}\text{C})$,
[1e]	a tensile strength of the electrolytic copper foil, which is measured after a heat treatment at a temperature of 190° C. for 1 hour, ranges from 21 to 36 kgf/mm ² ,
[1f]	a weight deviation of the electrolytic copper foil is 5% or less,
[1g]	a peak count (Pc) of each of the first and second surfaces of the electrolytic copper foil ranges from 3 to 92, and
[1h]	each of the first and second surfaces has a surface roughness (Rz) of 3.5 μm or less.
[2]	The electrolytic copper foil of claim 1, having an elongation of 3% or more at room temperature.
[3]	The electrolytic copper foil of claim 1, wherein each of the first and second protective layers includes at least one of chromium (Cr), a silane compound, and a nitrogen compound.
[4]	The electrolytic copper foil of claim 1, having a thickness of 4 to 30 μm .
[5]	The electrolytic copper foil of claim 1, having a coefficient of thermal expansion of 17.3 to 22 $\mu\text{m}/(\text{m}\cdot^{\circ}\text{C})$.

Limitation	Claim Language
[6pre]	A secondary battery electrode comprising:
[6a]	an electrolytic copper foil including a first surface and a second surface opposite the first surface; and
[6b]	a first active material layer on the first surface of the electrolytic copper foil,
[6c]	wherein the electrolytic copper foil comprises: a copper layer including a matte surface facing the first surface and a shiny surface facing the second surface; a first protective layer on the matte surface of the copper layer; and a second protective layer on the shiny surface of the copper layer, wherein a coefficient of thermal expansion of the electrolytic foil, which is measured using a TMA while heating the electrolytic copper foil from 30° C. to 190° C. at a speed of 5° C./min, ranges from 16 to 22 $\mu\text{m}/(\text{m} \cdot ^\circ \text{C})$, wherein a tensile strength of the electrolytic copper foil, which is measured after a heat treatment at a temperature of 190° C. for 1 hour, ranges from 21 to 36 kgf/mm², wherein a weight deviation of the electrolytic copper foil is 5% or less, wherein a peak count (Pc) of each of the first and second surfaces of the electrolytic copper foil ranges from 3 to 92, and wherein each of the first and second surfaces has a surface roughness (Rz) of 3.5 μm or less.
[7]	The secondary battery electrode of claim 6, wherein the first active material layer includes at least one active material selected from the group consisting of carbon, a metal (Me) such as Si, Ge, Sn, Li, Zn, Mg, Cd, Ce, Ni, or Fe, an alloy containing the metal (Me), an oxide of the metal (MeO _x), and a composite of the metal (Me) and carbon.
[8]	The secondary battery electrode of claim 6, wherein the first active material layer comprises Si.
[9]	The secondary battery electrode of claim 6, further comprising a second active material layer on the second protective layer.
[10pre]	A secondary battery comprising:

Limitation	Claim Language
[10a]	a cathode; an anode including a secondary battery electrode; an electrolyte configured to provide an environment in which lithium ions may move between the cathode and the anode; and a separator configured to electrically insulate the cathode from the anode,
[10b]	wherein the secondary battery electrode comprises: an electrolytic copper foil including a first surface and a second surface opposite the first surface; and a first active material layer on the first surface of the electrolytic copper foil, wherein the electrolytic copper foil comprises: a copper layer including a matte surface facing the first surface and a shiny surface facing the second surface; a first protective layer on the matte surface of the copper layer; and a second protective layer on the shiny surface of the copper layer, wherein a coefficient of thermal expansion of the electrolytic foil, which is measured using a TMA while heating the electrolytic copper foil from 30° C. to 190° C. at a speed of 5° C./min, ranges from 16 to 22 $\mu\text{m}/(\text{m} \cdot ^\circ \text{C}.)$, wherein a tensile strength of the electrolytic copper foil, which is measured after a heat treatment at a temperature of 190° C. for 1 hour, ranges from 21 to 36 kgf/mm², wherein a weight deviation of the electrolytic copper foil is 5% or less, wherein a peak count (Pc) of each of the first and second surfaces of the electrolytic copper foil ranges from 3 to 92, and wherein each of the first and second surfaces has a surface roughness (Rz) of 3.5 μm or less.

I. INTRODUCTION

Solus Advanced Materials Co., Ltd. (“Petitioner”) petitions for IPR of claims 1-10 (“Challenged Claims”) of U.S. Patent No. 10,811,689 (“the ’689 Patent”).

II. REQUIREMENTS FOR IPR

A. Grounds for Standing

Petitioner certifies that the ’689 Patent is available for IPR. Petitioner is not barred or estopped from requesting this review.

B. Challenge and Relief Requested

Petitioner requests IPR of the Challenged Claims on the below grounds. Dr. Randall provides supporting explanations in his Declaration (SOLUS-1003) cited throughout this petition. SOLUS-1003, ¶¶1-217.

Ground	Claims	Basis for Rejection
1	1-10	§103: Shinozaki in view of Khatibi and Toshio (or Kim)
2	1-10	§103: Kim in view of Khatibi and Griesi

As seen below, each reference applied in this Petition predates October 12, 2016 (“Critical Date”), which is the earliest filed foreign application from which the ’689 Patent claims priority. Petitioner does not necessarily agree that the ’689 Patent is entitled to priority to this Critical Date, but has applied references that

pre-date the Critical Date and qualify as prior art, as shown below. *See* SOLUS-1040.

Reference	Date	Section
Shinozaki	5/2/2013 (published)	102(a)(1), 102(a)(2)
Toshio	7/19/2013 (published)	102(a)(1), 102(a)(2)
Kim	5/2/2013 (published)	102(a)(1), 102(a)(2)
Griesi	12/15/2014 (published)	102(a)(1)
Khatibi	09/20/2006 (published)	102(a)(1)

III. SUMMARY OF THE '689 PATENT

A. Brief Description

The '689 Patent describes its purported “invention” as relating to an electrolytic copper foil “having improved handleability and capable of securing a secondary battery having a high durability.” SOLUS-1001, Abstract, 2:12-22.

The '689 Patent describes that the electrolytic copper foil includes a “first surface and a second surface opposite the first surface,” “copper layer having a matte surface facing the first surface and a shiny surface facing the second surface,” and a respective protective layer formed on each of the shiny surface and the matte surface. *Id.*, Abstract, 2:27-34. Further, the '689 Patent describes specific ranges of “coefficient of thermal expansion,” “tensile strength,” and “weight deviation” of the electrolytic copper foil, and specific ranges of “peak count” and “surface roughness (Rz)” of the first and second surfaces. *Id.*, Abstract, 2:34-54.

B. Prosecution History

The '689 Patent issued from U.S. Patent App. No. 15/696,360 (“the '360 application”). During prosecution, to overcome an obviousness rejection, the patentee added “peak count” element to claim 1 (by transferring the “peak count” element from dependent claim 3 to independent claim 1) of the '360 application. SOLUS-1002, 51. However, even with respect to this limitation, the examiner found that, based on prior art Hirose (US2008/0050652), “absent of unexpected results . . . the peak count . . . is an optimizable parameter for a result-effective variable.” *See id.*, 47. Given that both the “surface roughness [e.g., Rz]” (as disclosed in Hirose) and the “peak count” allegedly impact the same features that they aim to effect—“adhesion [between the electrolytic copper foil and the active material layers] and cracking on expansion”—the examiner’s interpretation suggests that those skilled in the art would have been motivated to optimize the specific “peak count” ranges claimed. *See id.*, 47. In allowing the patent, after an interview with a patentee’s representative, the examiner amended the claim to add the requirement that “each of the first and second surfaces has a surface roughness (Rz) of 3.5 μm or less” to claim 1, and thus did not resolve whether Hirose discloses the “peak count” limitation irrespective of the surface roughness (Rz). *See id.*, 13.

C. Level of Ordinary Skill in the Art

A person of ordinary skill in the art relating to the subject matter of the '689 Patent as of the Critical Date (a "POSITA") 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. SOLUS-1003, ¶10.

D. Claim Construction

Petitioner submits that all claim terms should be construed according to the *Phillips* standard. *Phillips v. AWH Corp.*, 415 F.3d 1303 (Fed. Cir. 2005); 37 C.F.R. § 42.100. Here, based on the evidence below and the prior art's description of the claimed elements being similar to that of the '689 Patent's specification, and because the Challenged Claims are obvious under any reasonable interpretation, no formal claim constructions are necessary in this proceeding because "claim terms

need only be construed to the extent necessary to resolve the controversy.”

Wellman, Inc. v. Eastman Chem. Co., 642 F.3d 1355, 1361 (Fed. Cir. 2011).¹

Further, Petitioner may argue in district court that uncertainty regarding the outer bounds of various limitations renders the ’689 Patent’s claims indefinite. Such lack of clarity, while inhibitive to an infringement analysis, is immaterial here. The obviousness grounds of this petition parallel the ’689 Patent’s preferred embodiments and thus, do not approach the periphery of claim scope.

¹ Petitioner is not conceding that each claim satisfies all statutory requirements, such as §§ 101 and 112, nor is Petitioner waiving any arguments concerning claim scope or grounds that can only be raised in district court. Indeed, the Board has held that it is not paralyzed against assessing whether an ambiguous claim term encompasses similar prior art structure for purposes of an anticipation/obviousness inquiry. *Mylan Pharm. Inc. v. Horizon Pharma USA, Inc.*, IPR2018-00272, Paper 35, 6-8 (PTAB 2019). The Board has regularly compared indefinite claims to the prior art for purposes of considering unpatentability. *See, e.g., Chicago Mercantile Exchange, Inc. v. 5th Market, Inc.*, CBM2013-00027, Paper 33, 3 (PTAB 2014) (holding that the claims were both indefinite and obvious); *SAP America, Inc. v. Lakshmi Arunachalam*, CBM2013-00013, Paper 61, 29 (PTAB 2014).

IV. THE CHALLENGED CLAIMS ARE UNPATENTABLE

A. [GROUND 1] – CLAIMS 1-10 ARE OBVIOUS OVER SHINOZAKI –KHATIBI–TOSHIO (OR KIM)

The sections below provide an introduction to Shinozaki, Khatibi, and Toshio (or Kim).² SOLUS-1003, ¶21.

Overview of Shinozaki

Shinozaki describes a current collector for use in secondary batteries. SOLUS-1004, Abstract. 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.” SOLUS-1004, Abstract; SOLUS-1003, ¶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 0.1-3µm is formed on both surfaces of an untreated copper foil by roughening treatment by means of electrolysis, and the

² Petitioner incorporates this discussion into Ground 1.

surface-roughened layers on both surfaces have a *surface roughness Rz^3 of 1.0-5 μm* and a *surface roughness Ra^4 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 .*⁵ SOLUS-1004, Abstract, [0029], [0031], [0032]; SOLUS-1003, ¶23.

In sum, Shinozaki particularly attributes the adhesion enhancement and other benefits to the following surface roughness characteristics of the electrolytic copper foil:

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

[2] Ra of 0.25-0.7 μm ; and

³ Rz represents the sum of the absolute values of the five highest peaks and the absolute values of the five lowest valleys, divided by 5. SOLUS-1016, 2; SOLUS-1017, 13; SOLUS-1018, 24-25; SOLUS-1003, ¶¶24-26.

⁴ Ra represents the average roughness of a surface, calculated as the mean deviation of the surface profile from the central mean line over a specified sampling length. SOLUS-1016, 1, 2; SOLUS-1003, ¶¶24-25, 27.

⁵ All emphases added.

[3] Both surfaces (matte surface and shiny surface) of electrolytic copper foil exhibiting similar roughness characteristics (*e.g.*, similar Rz and similar Ra). SOLUS-1004, Abstract, [0029], [0031], [0032], [0073], [0074].

Overview of Khatibi

Khatibi describes a study that investigates the characteristics of the coefficient of thermal expansion (CTE) of electrodeposited copper foils and rolled copper foils with thicknesses ranging from 12 μ m to 200 μ m. SOLUS-1006, Abstract; SOLUS-1003, ¶28.

Khatibi describes that “[t]he aim of present study was to outline the impact of manufacturing process of thin copper foils on the temperature dependency of E and CTE up to 200°C and investigate the correlation between their properties in this temperature range.” SOLUS-1006, 2⁶; SOLUS-1003, ¶29.

As part of the results of Khatibi’s study, the CTE of electrodeposited copper foils is shown as a function of test temperature. SOLUS-1006, 4, Table 2 (annotated, reproduced below). In Table 2, electrolytic copper foil is designated as DF. SOLUS-1006, 2; SOLUS-1003, ¶30.

⁶ Citations refer to page number of the PDF document.

Table 2: Results of E and CTE measurements for rolled and electrodeposited Cu foils as a function of test temperature

Designation	CTE(ppm/K)			E(GPa)		
	RT	100°C	200°C	RT	100°C	200°C
12µm-TPC-none	16,6	17,9	19,6	101		
18µm-TPC-none	14,8	20,3	27,6	100		
35µm-TPC-none	15,7	18,1	21,3	101		
12µm-TPC-300°C-30min	16,3	17,1	18,2	108	90	82
18µm-TPC-300°C-30min	17,1	18,1	19,7	101	84	77
35µm-TPC-300°C-30min	14,9	16,5	18,7	101	83	74
12µm-TPC-900°C-30min	15,5	17,2	19,5	87	75	68
18µm-TPC-900°C-30min	17,2	18,2	19,6	74	74	68
35µm-TPC-900°C-30min	14,3	17,1	20,9	79	61	68
12µm-DF-300°C-30min				111	98	69
18µm-DF-300°C-30min				93	87	67
35µm-DF-300°C-30min				96	79	58
12µm-DF-900°C-30min	15,8	16,9	18,39	105	84	68
18µm-DF-900°C-30min	17,1	18,0	19,2	86	77	58
35µm-DF-900°C-30min	16,9	17,4	18,1	90	69	61
200µm-DF-300°C-30min	16,7	16,8	16,9	120	106	91
Bulk copper	16,6	17,4	18,0	93	96	86

SOLUS-1006, Table 2

As described above and shown in Table 2, Khatibi discloses the characteristics of CTE of electrodeposited copper foils as a function of temperature and thickness. SOLUS-1003, ¶31.

Overview of Toshio

Toshio describes a current collector for use in secondary batteries. SOLUS-1014⁷, Abstract; SOLUS-1003, ¶32.

Toshio also describes an electrolytic copper foil having surface(s) that undergo a roughening process. *Id.*, [0054]. Relatedly, Toshio focuses on improving cycle characteristics of a 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]; SOLUS-1003, ¶33.

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]; SOLUS-1003, ¶34.

Overview of Kim

Kim describes a current collector for use in secondary batteries. SOLUS-1012, Abstract; SOLUS-1003, ¶35.

⁷ KR 2014/012942 to Toshio (SOLUS-1013) was published in Korean. Thus, all citations to Toshio are to its English translation (SOLUS-1014).

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. SOLUS-1012, Abstract, [0010], [0026]; SOLUS-1003, ¶36.

Kim further describes that using a protective layer including a chromate layer provides advantages including corrosion prevention. *See, e.g.*, SOLUS-1012, [0007], [0024], [0025], [0028]; SOLUS-1003, ¶37.

Reasons for combining Shinozaki with Toshio or Kim

A POSITA would have been motivated to apply Toshio's or Kim's teachings regarding protective layer(s) to Shinozaki's electrolytic copper foil for a current collector and would have expected success, as described below. SOLUS-1003, ¶38.

First, as described above, both Shinozaki and Toshio or Kim describe use of electrolytic copper foil for a current collector for a secondary battery. SOLUS-1003, ¶39.

Second, as described above, both Shinozaki and Toshio or Kim describe 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]; SOLUS-1003, ¶40.

Third, as described above, Shinozaki and Toshio or Kim share the same goal of enhancing adhesion between the current collector and the active material. Further, as described above, both Shinozaki and Toshio share the same goal of preventing wrinkles on surfaces of copper foil for a current collector. SOLUS-1003, ¶41.

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. SOLUS-1003, ¶42.

Fifth, as explained by Dr. Randall, applying protective layer(s) such as a chromate layer, a benzotriazole layer, or a silane coupling treatment layer on the copper foil was conventional. SOLUS-1003, ¶43.

At least for the reasons set forth above, a POSITA would have been motivated to apply Toshio’s or Kim’s teachings regarding protective layer to

Shinozaki's electrolytic copper foil for a current collector, and would have expected success. SOLUS-1003, ¶44.

Notes about Khatibi in the Shinozaki-Toshio (or Kim) combination

As described above, Khatibi discloses the CTE values and characteristics of electrodeposited copper foils as a function of temperature and thickness. More specifically, Khatibi provides CTE values for copper foil thickness ranging from 12-300µm as a function temperature. SOLUS-1003, ¶45.

In the combination, Shinozaki discloses a copper foil having a thickness ranging from 8µm to 20µm. SOLUS-1004, [0072], [0073]; SOLUS-1003, ¶46.

Accordingly, because Khatibi discloses the characteristics of the CTE of electrolytic copper foils having thicknesses similar to (or overlapping with) those of Shinozaki's electrolytic copper foils, Khatibi is a relevant disclosure that can relate to the CTE of Shinozaki's electrolytic copper foils in the combination. SOLUS-1003, ¶47.

1. Analysis

(i) Claim 1

[1pre]

To the extent the preamble is deemed limiting, Shinozaki renders this preamble obvious. SOLUS-1003, ¶48.

Shinozaki specifically discloses “an electrolytic copper foil for a lithium ion secondary battery.” SOLUS-1004, Abstract; SOLUS-1003, ¶48.

Shinozaki discloses the first surface and second surface opposite to the first surface of electrolytic copper foil. *See* SOLUS-1004, [0031]; SOLUS-1003, ¶49.

[1a]

Shinozaki discloses “an untreated copper foil, on the both front and back surfaces, on the both front and back surfaces of which relief (uneven) roughened layers comprised of copper or copper alloy.” SOLUS-1004, [0031]; SOLUS-1003, ¶50.

Shinozaki describes that “the surface contacting a titanium roll (cathode)” is a “shiny surface or S surface” and “the surface contacting the electrolytic solution” is a “matte surface or M surface.” SOLUS-1004, [0054]; SOLUS-1003, ¶51.

[1b]-[1c]

In the combination, Toshio or Kim renders obvious [1b]-[1c]; SOLUS-1003, ¶52.

Specifically, as described in Toshio and conventionally understood by a POSITA, [1] active material 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. SOLUS-1014, claim 6, claim 9, claim 10, [0031], [0074], [0092]-[0093]; SOLUS-1003, ¶53.

Further, as explained by Dr. Randall, it would have been obvious for a POSITA to apply the protective layer to both surfaces of the copper foil when said POSITA aims to achieve rust prevention between the copper foil surface of the current collector and the active material for electrodes of secondary batteries. SOLUS-1003, ¶54.

Alternatively/additionally, as described above with respect to 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 to achieve the same anti-corrosion effect on both surfaces of the copper foil. *See* discussion *supra* section Overview of Kim; SOLUS-1012, [0007], [0024], [0025], [0028]; SOLUS-1003, ¶55.

[1d]

As described above, because Khatibi discloses the characteristics of the CTE of electrolytic copper foils having thicknesses similar to (or overlapping with) those of Shinozaki's electrolytic copper foils, Khatibi is a relevant disclosure that can relate to the CTE of Shinozaki's electrolytic copper foils in the combination.

See discussion *supra* section Overview of Khatibi and section Notes about Khatibi in the Shinozaki-Toshio (or Kim) combination. SOLUS-1003, ¶56.

Further, Khatibi discloses CTE values that fall within the claimed range. For instance, Khatibi discloses CTE values such as 15.8 ppm/K (corresponding to $15.8 \mu\text{m}/(\text{m}\cdot^{\circ}\text{C}))$), 16.9 ppm/K, and 18.39 ppm/K at 25 °C (room temperature), 100 °C, and 200 °C, respectively, for the electrolytic copper foil having a thickness of 12 μm . *See* SOLUS-1006, Table 2 (annotated, reproduced below). Moreover, for instance, Khatibi discloses CTE values such as 17.1 ppm/K, 18.0 ppm/K, and 19.2 ppm/K at 25 °C, 100 °C, and 200 °C, respectively, for the electrolytic copper foil having a thickness of 18 μm . *Id.* As explained by Dr. Randall, while the claim limitation [1d] recites “measured using a thermomechanical analyzer (TMA),” this is unlikely to significantly impact the CTE value, as variations in equipment and a heating speed of 5°C/min would not significantly alter the results. SOLUS-1003, ¶¶56-58. Further, as Dr. Randall notes: “all of the CTE values for bulk copper are within the claimed range of [1d] as well” meaning that there is nothing special or inventive about the claimed range of CTE for copper of 16 to 22 $\mu\text{m}/\text{m}\cdot^{\circ}\text{C}$. SOLUS-1003, ¶57 (citing SOLUS-1006, Table 2; SOLUS-1035; SOLUS 1036).

Table 2: Results of E and CTE measurements for rolled and electrodeposited Cu foils as a function of test temperature

Designation	CTE(ppm/K)			E(GPa)		
	RT	100°C	200°C	RT	100°C	200°C
12µm-TPC-none	16,6	17,9	19,6	101		
18µm-TPC-none	14,8	20,3	27,6	100		
35µm-TPC-none	15,7	18,1	21,3	101		
12µm-TPC-300°C-30min	16,3	17,1	18,2	108	90	82
18µm-TPC-300°C-30min	17,1	18,1	19,7	101	84	77
35µm-TPC-300°C-30min	14,9	16,5	18,7	101	83	74
12µm-TPC-900°C-30min	15,5	17,2	19,5	87	75	68
18µm-TPC-900°C-30min	17,2	18,2	19,6	74	74	68
35µm-TPC-900°C-30min	14,3	17,1	20,9	79	61	68
12µm-DF-300°C-30min				111	98	69
18µm-DF-300°C-30min				93	87	67
35µm-DF-300°C-30min				96	79	58
12µm-DF-900°C-30min	15,8	16,9	18,39	105	84	68
18µm-DF-900°C-30min	17,1	18,0	19,2	86	77	58
35µm-DF-900°C-30min	16,9	17,4	18,1	90	69	61
200µm-DF-300°C-30min	16,7	16,8	16,9	120	106	91
Bulk copper	16,6	17,4	18,0	93	96	86

SOLUS-1006, Table 2

Moreover, “heating the electrolytic copper foil from 30° C. to 190° C. at a speed of 5° C./min” would have produced CTE values similar to Khatibi’s CTE values at 25 °C, 100 °C, and 200 °C, as Khatibi’s temperature range of 25-200 °C is comparable to the 30-190° C range recited in claim 1. SOLUS-1006, Table 2. Dr. Randall explains that the “heating rate (the heating rate (5°C per minute) is typical for certain devices used to measure material expansion, such as a TMA (Thermomechanical Analyzer) or a dilatometer. Typically, these devices use ramp rates between 2°C and 20°C per minute, so the ‘5° C./min’ recited in [1d] is common and should not drastically affect the measurement results.” SOLUS-1006, 3; SOLUS-1003, ¶59.

Additionally, Khatibi Table 2 discloses that electrolytic copper foils with thicknesses ranging from 12 μm to 200 μm exhibit CTE values at room temperature (RT (25 °C)), 100 °C, and 200 °C that fall within the claimed range of 16 to 22 $\mu\text{m}/(\text{m}\cdot^{\circ}\text{C})$. As explained by Dr. Randall, the claimed range of 16 to 22 $\mu\text{m}/(\text{m}\cdot^{\circ}\text{C})$ is quite broad, to the point that the range encompasses copper foils, bulk copper, and many copper alloys, and thus should at least be considered representative of the CTE characteristics of electrolytic copper foil within this thickness and temperature range. SOLUS-1006, Table 2; SOLUS-1003, ¶60.

[1e]

Shinozaki describes that “the copper foil is preferably electrolytic copper foil which has . . . a tensile strength of 300 N/mm² or more at ordinary temperature . . . a tensile strength after an elapse of 15 hours at 150° C. of 250 N/mm² or more” SOLUS-1004, [0050]. Accordingly, Shinozaki discloses tensile strength of the electrolytic copper foil being **30.6kgf/mm²** (equivalent to 300 N/mm) and **25.5kgf/mm²** (equivalent to 250N/mm²). Moreover, Shinozaki Table 2 lists the tensile strength of untreated copper foil, ranging from **25.5 kgf/mm² to 28.6 kgf/mm²** after an elapse of 15 hours at 150° C (converted from a range of 250-280 N/mm²) and **31.6 kgf/mm² to 40.8 kgf/mm²** at room temperature (converted from a range of 310-400 N/mm²). SOLUS-1004, Table 2. As explained by Dr. Randall, the claimed tensile strength ranging from 21 to 36 kgf/mm² indicates a broad

range, and a heating temperature of 190° C for 1 hour would have had insignificant effect on changes on tensile strength compared to Shinozaki's heating temperature of 150° C for 15 hours. Additionally, this is supported by other prior art (e.g., Sano), where the majority (12 out of 17) of the high temperature (180°C) tensile strength data for the copper foils disclosed fall within the range of 21 to 36 kgf/mm² as well, and the remaining data bracket the claimed range of 21 to 36 kgf/mm² on both the high and the low ends, thereby encompassing the entire claimed range of [1e]. SOLUS-1008, Table 2; SOLUS-1003, ¶61.

Further, as explained by Dr. Randall, roughening treatment of the copper foil surface would likely have had an insignificant effect on the mechanical properties (e.g., tensile strength of the copper foil), thus complying with the teachings of Shinozaki. SOLUS-1003, ¶62.

[1f]

In the combination, Kim renders obvious this limitation. SOLUS-1003, ¶63.

First, as described above, both Shinozaki and Kim share a common goal of preventing wrinkles on surfaces of copper foil for a current collector. SOLUS-1004, Abstract.; SOLUS-1012, [0010]; SOLUS-1003, ¶64.

Second, Kim attributes wrinkle prevention to controlling of weight deviation of copper foil to 3% or less. SOLUS-1012, claim 3, [0028], Table 1, [0031]; SOLUS-1003, ¶65.

Third, prior art (Hara) further describes and suggests the use of an electrolytic copper foil having the weight variation or “weight deviation” that is “2% or less,” highlighting its advantages in improving battery performance and cycle life characteristics. SOLUS-1029,⁸ claim 1, [0048], [0050], [0011]. Further, Hara describes in one of their examples that such electrolytic copper foil with the desired weight deviation of “2% or less” is obtained from commercially available suppliers such as “Furukawa Circuit Foil Co., Ltd.” *Id.*, [0027]; SOLUS-1003, ¶66.

At least for the reasons set forth above, the combination renders obvious this claim limitation. SOLUS-1003, ¶67.

[1g]

As an initial matter, the specification of ’689 Patent defines and describes the “peak count (Pc)” as follows:

In the present invention, the “peak count (Pc)” may be obtained by measuring peak counts (Pc) of any three points on the surface of the electrolytic copper foil 110 and calculating an average value of measured values of the peak counts (Pc). The peak count (Pc) of each of the points is the *number of effective peaks* P1, P2, P3, and P4

⁸ JP 2003/051340A to Hara (SOLUS-1028) was published in Japanese. Thus, all citations to Hara are to its English translation (SOLUS-1029).

which *rise above a 0.5 μm upper criteria line C1 per 4 mm unit sample length* in a surface roughness profile obtained according to U.S. standard ASME B46.1-2009. In this case, at least one valley deeper than a *-0.5 μm lower criteria line C2* exists between adjacent effective peaks among the effective peaks. *When there is no valley deeper than the -0.5 μm lower criteria line C2 between adjacent peaks which rise above the upper criteria line C1, all of the adjacent peaks may not be “effective peaks” used for measuring the peak count (Pc), and relatively lower peaks among the peaks are ignored when obtaining the number of “effective peaks.”*

SOLUS-1001, 7:43-59; SOLUS-1003, ¶68.

This peak count (Pc) can be deemed identical to the Rpc (peak count roughness) feature described in the inventor's other issued patent, U.S. Patent No. 10,480,090 (the '090 Patent). For instance, the '090 Patent describes Rpc as follows:

the peak count roughness Rpc of each of the first and second surfaces is an average of peak count roughness Rpc values measured at randomly-selected three points, the peak count roughness Rpc 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.

SOLUS-1027, claim 1; SOLUS-1003, ¶69.

Therefore, Pc and Rpc share the same definition. As explained below and further confirmed by Dr. Randall, Pc or Rpc is a well-recognized parameter shared

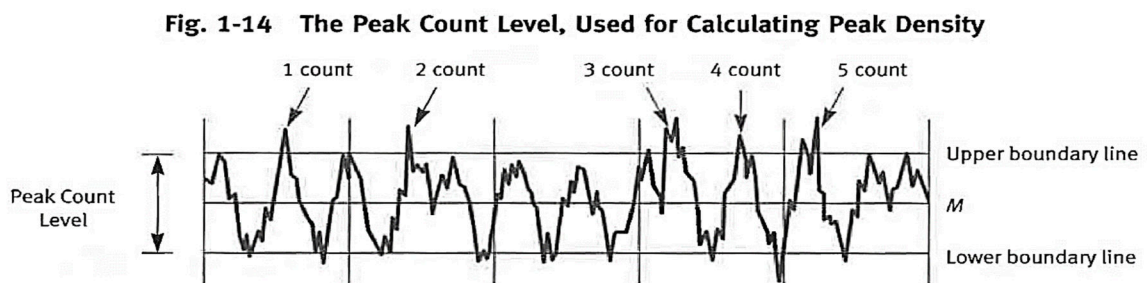
among various standards. Thus, “peak count (Pc)” can be considered equivalent to “peak count roughness (Rpc),” and these terms can be used interchangeably.

SOLUS-1003, ¶70.

At least for the reasons described below, Shinozaki renders this claim limitation obvious. SOLUS-1003, ¶71.

1. Pc (peak count) or Rpc (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) “upper criteria line” and (ii) “lower criteria line” per (iii) “unit sampling length”

First, as described in the specification of the ’689 Patent, ASME B46.1 (2009) standard refers to “peak density or “Pc” and describes that “the number of SAE [Society of Automotive Engineers] peaks per unit length measured at a specified peak count level over the evaluation length,” in which SAE peak corresponds to 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). SOLUS-1003, ¶72.



SOLUS-1021, FIG. 1-14

Second, various prior art describe that different surface measurement standards, such as ASME B46.1 (1985) and SEP 1940, share the same definition of Pc or Rpc, as mentioned in the specification of the '689 patent. SOLUS-1025, FIG. 6 (reproduced below), [0050]; SOLUS-1020, 41; SOLUS-1003, ¶73.

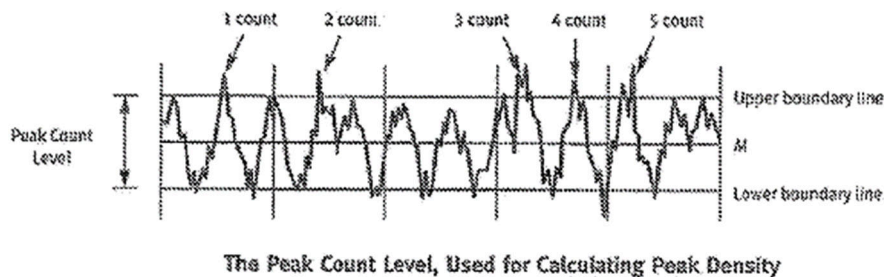


FIGURE 6
SOLUS-1025, FIG. 6

Third, an instruction manual for commonly used surface profile measurement equipment (e.g., MarSurf M300) further supports the fact that Rpc (or Pc) is a well-recognized measurement parameter shared among various standards. For instance, the MarSurf M300 instruction manual describes that Rpc is shared by number of different surface roughness measurement standards including “EN 10049: 2005, ASME B46. 1 2002; E DIN EN ISO 4287/A1: 200707 (D).” SOLUS-1020, 41; SOLUS-1003, ¶74.

Accordingly, Pc or Rpc, as claimed in the '689 Patent, is a well-recognized parameter shared among various standards. SOLUS-1003, ¶75.

2. P_c or R_{pc} can be obtained from other surface roughness parameters such as R_{sm} or S_m (e.g., S_m of JIS B 0601)

First, a measurement standard (DIN EN ISO 4287) known to share the same definition of P_c or R_{pc} , describes that P_c (or R_{pc}) and R_{sm} are inversely related to each other and thus one can be calculated from the other. For instance, P_c or $R_{pc} = L / R_{sm}$, where L is a reference length (e.g., 4 mm as described in the '689 Patent's specification (SOLUS-1001 at 7:43-59)) and R_{sm} is a "mean value of the profile element widths X_s ." See SOLUS-1019, 20, 21, FIG. 10 (reproduced below); SOLUS-1003, ¶76.

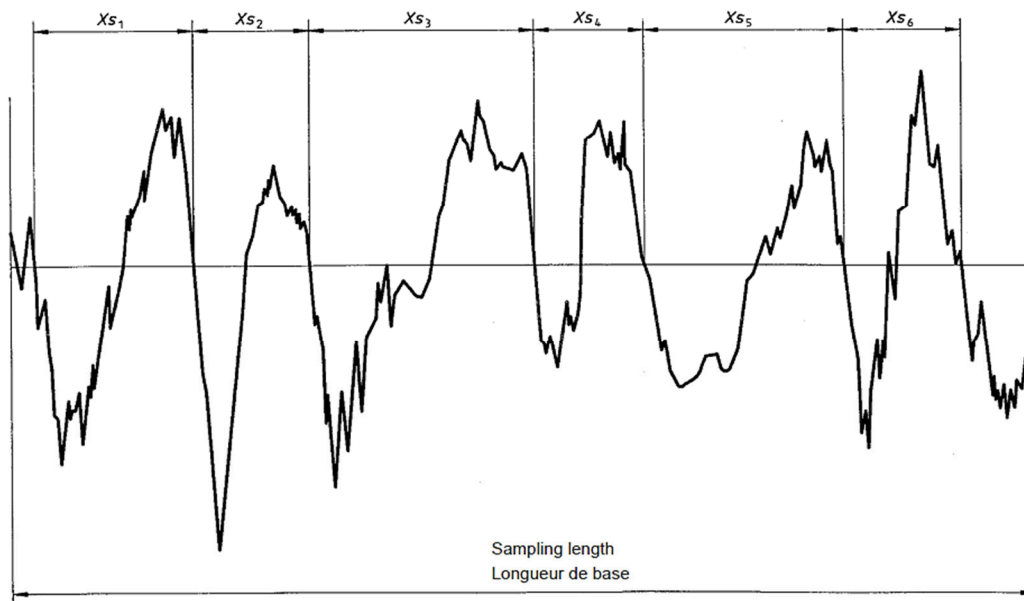


Figure 10 — Width of profile elements
Figure 10 — Largeur des éléments du profil

SOLUS-1019, FIG. 10

In other words, as explained by Dr. Randall, [1] R_{sm} represents the average distance between pairs of consecutive peaks and valleys 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 total length. SOLUS-1003, ¶77.

Second, an instruction manual of a commonly used surface profile measurement equipment (e.g., the MahrSurf M300) further confirms that P_c or R_{pc} can be calculated from R_{sm} , as described in DIN EN ISO 4287. For instance, MahrSurf M300 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 C_1 and then fall short of the lower C_2 ,” where R_{sm} is “[m]ean width . . . of profile elements (formerly: groove spacing).” SOLUS-1020, 41; SOLUS-1003, ¶78.

Third, R_{sm} is also known as S_m . For example, commonly used surface profile measurement equipment (e.g., the MahrSurf M300) instruction manual discloses that R_{sm} is shared among different standards, including “JIS B 0601” (both 1994 and 2001 versions). SOLUS-1020, 41. According to the specification of the JIS B 0601(1994), S_m is disclosed, having a definition that is equivalent to R_{sm} as defined above, and as shown below. SOLUS-1017, 16; SOLUS-1023; SOLUS-1003, ¶79. In the relationships illustrated below, $n = m$ and $S_{mi} = X_{Si}$ as per their respective definitions.

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

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

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

SOLUS-1003, ¶79

Accordingly, Pc or Rpc can be obtained from other surface roughness parameters, such as Rsm or Sm . SOLUS-1003, ¶80.

3. Shinozaki discloses Sm values that can be converted to Pc or Rpc values that fall within the claimed range of “3 to 92”

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 Rz of 1.0-5 μm ;

[2] Ra 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 Rz and similar Ra).

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

For instance, Shinozaki discloses example data 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]; SOLUS-1003, ¶81.

As explained below, Dr. Randall provides two different approaches, the latter approach being more mathematically precise and rigorous than the former, to [1] confirm that Shinozaki's example data (e.g., from Working Example 6) exhibits a Pc value that falls within the claimed range of "Pc of 3 to 92" and [2] present other data of Shinozaki that exhibit Pc values that fall within the claimed range. SOLUS-1003, ¶82.

First, Dr. Randall explains that Pc can be approximated based on Sm value and Ra value disclosed in the example data of Shinozaki. For example, Sm value of the example data (e.g., Working Example 6) of Shinozaki can be converted to Pc (or Rpc) value of 40 by using Ra value as proxy for the upper and lower criteria lines of $\pm 0.5 \mu\text{m}$. *Id.*, ¶83.

More specifically, as described above, Sm (e.g., Sm of JIS B0601) can be converted to Pc based on the following equation: $\text{Pc (or Rpc)} = L / \text{Sm}$. 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 $\text{Pc (or Rpc)} = 4 \text{ mm} / 50.00 \mu\text{m} = 80$ effective peaks. SOLUS-1004, Table 3. However, because the limitation requires "upper criteria line of 0.5 μm " and

“lower criteria line of $-0.5\text{ }\mu\text{m}$,” the Pc value would yield a maximum value of 80 for Shinozaki’s Working Example 6. SOLUS-1003, ¶83.

Then, an Ra value of $0.46\text{ }\mu\text{m}$ of Shinozaki’s Working Example 6 (which becomes $0.5\text{ }\mu\text{m}$ when rounded to the number of significant figures disclosed in the ‘689 Patent for upper and lower criteria (SOLUS-1001, 7:49-54)) can be used toward estimating Pc that satisfies the limitations regarding “upper criteria line of $0.5\text{ }\mu\text{m}$ ” and “lower criteria line of $-0.5\text{ }\mu\text{m}$.” As explained by Dr. Randall, Ra represents the average height deviation from the mean line of the surface over a specified sampling length. Therefore, the Ra value ($\approx 0.5\text{ }\mu\text{m}$) can be used as a reliable proxy for the upper and lower 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 Ra or upper/lower criteria lines of $\pm 0.5\text{ }\mu\text{m}$. Thus, Pc or the peak count derived above without considering the upper/lower criteria lines of $\pm 0.5\text{ }\mu\text{m}$ would be halved when considering Working Example 6. For instance, now the calculation would yield $\text{Pc} = 4\text{ mm} / (50.00\text{ }\mu\text{m} \times 2) = 40$ effective peaks. SOLUS-1003, ¶84.

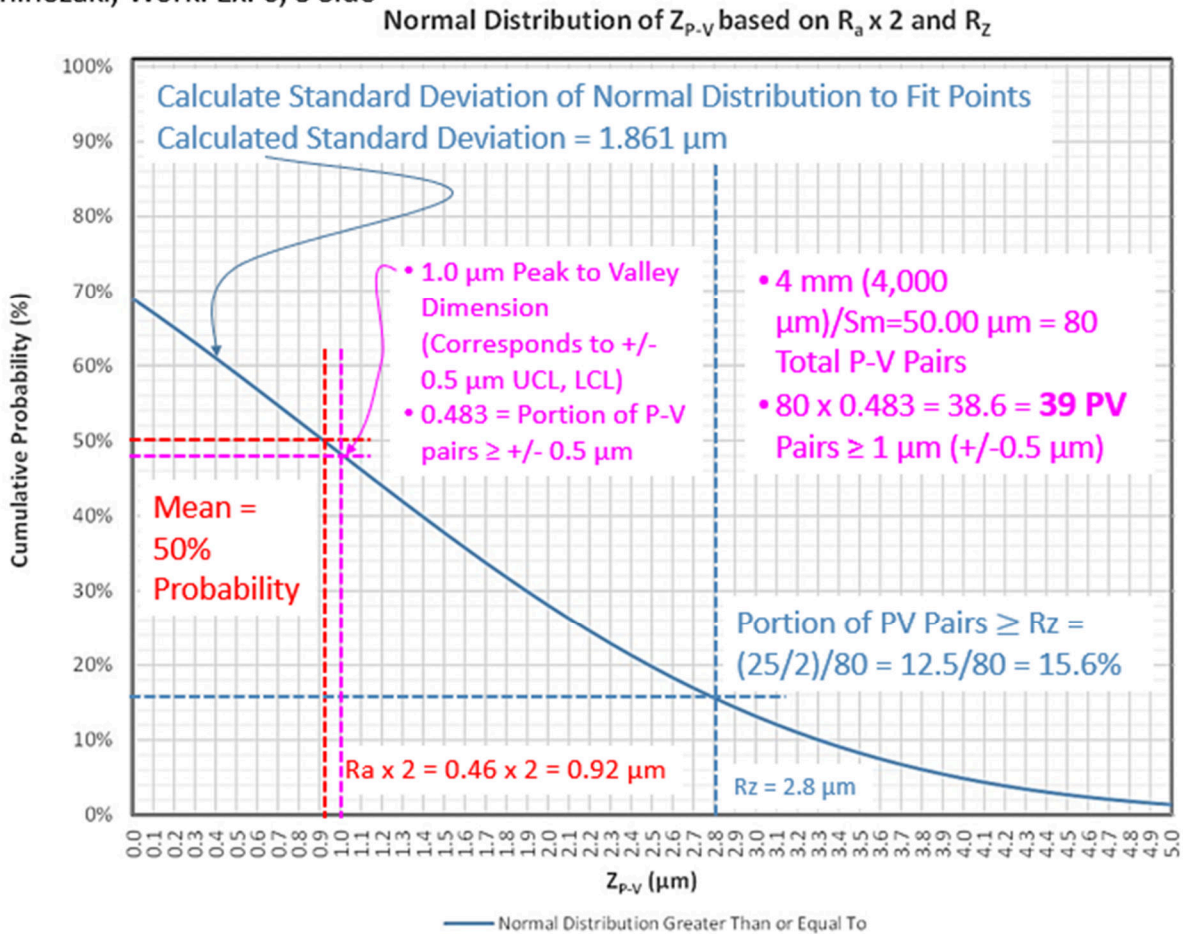
Further, Dr. Randall explains that a POSITA would have understood that these 40 effective peaks would not always have peaks and valleys which consecutively exceed (e.g., peak-valley-peak-valley consecutive sequence) these

criteria, so the actual Pc is likely to be slightly less than, if not equal to, the Pc 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 Pc of approximately 40, which falls within the claimed range of “3 to 92.” SOLUS-1003, ¶85.

Second, to help further validate the Pc determination approaches above, Dr. Randall provides a more mathematically rigorous approach to determine or otherwise confirm that the data disclosed in Shinozaki exhibit Pc values falling within the claimed range. For instance, “[t]he Gaussian (normal) distribution has become one of the mainstays of surface classification.” SOLUS- 1024, 4; SOLUS-1003, ¶86. Based on performing Gaussian distribution, Table 3 of Shinozaki has been re-developed, and the Pc of Working Example 6 is estimated to be 39.

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 (e.g., distance), and the y-axis represents the cumulative probability corresponding to proportion of peak-valley pairs with height greater than or equal to peak-to-valley pair height specified on the x-axis. SOLUS-1003, ¶87.

Shinozaki, Work. Ex. 6, S Side



SOLUS-1003, ¶87

Dr. Randall explains that 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 of the surface profile, corresponding to the x-axis value (e.g., 0.92 μm for Shinozaki's Working Example 6) at y-axis value indicating 50% cumulative probability;

[2] Utilizing Rz value (average peak-to-valley height (dimension) 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 greater than Rz, while the other half will have a height less than Rz. Accordingly, 12.5 peak-valley pairs correspond to the proportion of peak-to-valley height 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 (Ra x 2, 50% cumulative probability) and 2nd pair (Rz, calculated cumulative probability)] to determine the associated standard deviation and to establish the normal distribution. SOLUS-1003, ¶88.

Once the normal distribution is established, 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 that rises above and falls below the upper and lower criteria lines of $\pm 0.5 \mu\text{m}$. Thereafter, Pc or the peak count (derived from Sm without considering the upper/lower criteria lines of $\pm 0.5 \mu\text{m}$) can be multiplied by the cumulative probability to determine the Pc (effective peaks, peak-valley pairs) value that satisfies the upper and lower criteria lines of $\pm 0.5 \mu\text{m}$. SOLUS-1003, ¶89.

Ultimately, as Dr. Randall goes to explain more in detail in his declaration, a POSITA would have understood that, given the Ra, Rz and Sm values disclosed in Shinozaki (e.g., at Table 3), it would have been straightforward to calculate the number of peaks, and thus the peak count (Pc) of the copper foils using the appropriate application of normal statistics. SOLUS-1003, ¶¶90-98. As a result, the table below shows calculated Pc (or Rpc) values based on the data in Shinozaki Table 3. SOLUS-1003, ¶98. As shown, the calculated Pc (or Rpc) of Working Example 6 corresponds to 39 and 71 for the S surface and M surface, respectively. Additionally, the calculated Pc of Working Example 5 corresponds to 64 and 15 for S surface and M surface, respectively, and the calculated Pc (or Rpc) of Working Examples 1 and 3 for M surface corresponds to 87 and 78, respectively. SOLUS-1003, ¶98

		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

SOLUS-1003, ¶98.

Accordingly, Shinozaki's Pc values (that satisfy the teachings of Shinozaki) fall within the claimed range of Pc of "3 to 92." These specific Pc values disclosed by Shinozaki are thus a relevant disclosure for the recited range of Pc values. *See Ineos USA LLC v. Berry Plastics Corp.*, 783 F.3d 865, 869 (Fed. Cir. 2015) ("When a patent claims a range, as in this case, that range is anticipated by a prior art reference if the reference discloses a point within the range"); *Titanium Metals*

Corp. of Am. v. Banner, 778 F.2d 775, 782 (Fed. Cir. 1985); *In re Petering*, 301 F.2d 676, 682, 49 C.C.P.A. 993, 1001, 133 USPQ 275, 280 (1962)). Thus, the combination renders obvious the electrolytic copper foil having a surface with Pc of “3 to 92.” SOLUS-1003, ¶99.

Further, regarding the ’689 Patent’s description that “the “peak count (Pc)” may be obtained by measuring peak counts (Pc) of any three points on the surface of the electrolytic copper foil 110 and calculating an average value of measured values of the peak counts (Pc),” Sm, which is correlated with and can be used to calculate or derive Pc, is an average value of Sm values measured at multiple randomly selected points. *See* SOLUS-1017, 16-18. Dr. Randall explains that 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. SOLUS-1003, ¶100 (citing SOLUS-1017, 3, 10, 12, 15, 18, 21, 24, 27).

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 Pc values to both sides of the electrolytic copper foil. SOLUS-1004, [0122], [0073], [0074]; SOLUS-1008, [0005], [0008]; SOLUS-1009, 1:12-18; SOLUS-1003, ¶101.

At least for these reasons, the combination renders obvious this claim

limitation obvious. SOLUS-1003, ¶102.

4. Alternatively/additionally, a POSITA [1] would've recognized that Pc or Rpc is a recognized, result-effective variable, and [2] would've been motivated to further optimize Pc or Rpc or otherwise confirm whether Pc in Shinozaki aligns with Shinozaki's teachings of other surface roughness parameter values

At least for the reasons described below, Pc or Rpc 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]; SOLUS-1003, ¶103.

First, it was well-known that “[b]y controlling spacing parameters [e.g., roughness parameters such as Pc (or Rpc), Rsm (or Sm), etc.] it is possible to obtain better bounding [e.g., bonding] of finishes, more uniform finish of plating.” SOLUS-1016, 7. For instance, prior art (Gadelmawla) 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.*; SOLUS-1003, ¶104 (explaining “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 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”).

Second, although Pc (or Rpc) 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 Ra (the average height of the surface roughness from the mean line). Particularly, as described in the specification of the '689 Patent, peaks are counted as “effective peaks” only if they satisfy a consecutive height threshold requirement of “0.5 μm upper criteria line C1” and “–0.5 μm lower criteria line C2.” Therefore, if Pc’s upper/lower criteria lines are set to values such as $\pm 0.5 \mu\text{m}$ that are similar to average height Ra value(s) taught in Shinozaki (e.g., Ra of 0.25-0.7 μm), then Pc becomes correlated with Ra, as they both express height characteristics. *Id.*; SOLUS-1003, ¶105 (stating that “Ra and Pc are correlated in certain scenarios. One scenario corresponds to the following: when average height Ra of surface roughness is near 0.5 μm , and Rpc 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 Pc”). This indicates that:

[1] By controlling 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 Pc can also be correlated with the objective of controlling Ra (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. SOLUS-1003, ¶105 (citing SOLUS-1004, [0044], [0045], [0073], [0074]; SOLUS-1032; SOLUS-1033).

Third, it was demonstrated that Pc 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 Pc or 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, 8, 11, FIGS. 8, 11. Further, prior art (Fabian) simultaneously discloses [1] copper deposits that can be used for printed circuit board (PCB) and microelectronics, which can be

compatible with use in secondary batteries and [2] Pc (or R_{pc}) values of the copper foil that fall within the claimed Pc range, describing that such Pc 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]; SOLUS-1003, ¶105.

Accordingly, as described above by Gadelmawla, Fabian, and Dr. Randall, a POSITA [1] would've recognized that Pc is a result-effective variable that affects adhesion properties of electrolytic copper foil and [2] would've been motivated to further optimize Pc or otherwise confirm whether Pc in Shinozaki's copper foil aligns with Shinozaki's teachings of other surface roughness parameter values.

The rationale is summarized as follows:

- [i] Pc (or R_{pc}) 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 Pc, 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 Pc based on 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., Ra);

[iv] in many instances, the objective of controlling Pc can also be correlated with the objective of controlling Ra (average surface roughness);

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

[vi] Pc values⁹, such as 33.1¹⁰ and 33.3¹¹ 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

Shinozaki (e.g., providing void-reduced surface to enhance adhesion

⁹ 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. Dr. Randall explains that, unless otherwise specified by Fabian, Fabian should have followed this recommendation and use the $\pm 0.5 \mu\text{m}$ criteria lines. SOLUS-DIN, 18, 19; SOLUS-1003, ¶106.

¹⁰ Converted from 82.75 peaks / 1 cm to 33.1 peaks / 4 mm. SOLUS-1005, 8, Table 6; SOLUS-1003, ¶106.

¹¹ Converted from 83.38 peaks / 1 cm to 33.3 peaks / 4 mm. SOLUS-1005, 8, Table 6; SOLUS-1003, ¶106.

properties). *See* SOLUS-1016, 7; SOLUS-1005, Abstract, 8, 11, FIGS. 8, 11; SOLUS-1004, [0073]; SOLUS-1003, ¶106.

Further, a POSITA would have expected success in optimizing Pc, at least for the following reasons. SOLUS-1003, ¶107.

First, as explained by Dr. Randall and prior art, the optimization of Pc would have involved a mere routine optimization of electrodeposition conditions, such as varying concentrations of additives (e.g., organic additives), the 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 Pc values. SOLUS-1005, Abstract, 8, FIGS. 8, 11. 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 Sm or Rsm values, which are directly correlated with Pc values. SOLUS-1007, Table 4 (demonstrating comparison of Rsm 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); SOLUS-1003, ¶108.

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., Pc of 33.1 and 33.3 of Fabian) that fall within the claimed range (Pc of 3-92), thereby contributing to the reasonable expectation of success and the rationale for obviousness. *In re Boesch*, 617 F.2d 272, 276 (C.C.P.A. 1980); SOLUS-1005, Abstract, 8, FIGS. 8, 11; SOLUS-1003, ¶109.

Third, as described above, because Pc's recommended upper and lower criteria threshold 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 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 Pc (or 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 ± 0.5 μm). Accordingly, as explained by Dr. Randall, a POSITA would have known to control 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. SOLUS-1005, 7-8; SOLUS-1003, ¶110.

Fourth, as described above with respect to motivation to optimize Pc, advantages of optimizing Pc were well-demonstrated in prior art. For instance, [1] it was known to use Pc “to obtain better bounding of finishes, more uniform finish of plating,” [2] it was known that peak spacing (that is correlated to Pc, 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 Pc to enhance uniformity or void reduction of copper foil surface. SOLUS-1016, 7; SOLUS-1005, Abstract, 8, 11, FIGS. 8, 11; SOLUS-1004, [0073]; SOLUS-1003, ¶111.

Therefore, a POSITA [1] would have known that Pc is a recognized, result-effective variable, and [2] would have been motivated to further optimize Pc in addition to Shinozaki’s teachings of other surface roughness parameter value(s). *See In re Aller*, 220 F.2d 454 (CCPA 1955) (“where the general conditions of a claim are disclosed in the prior art, it is not inventive to discover the optimum or workable ranges by routine experimentation”); *see also In re Applied Materials, Inc.*, 692 F.3d 1289, 1297 (Fed. Cir. 2012) (“A recognition in the prior art that a property is affected by the variable is sufficient to find the variable result-effective”); *see also KSR International Co. v. Teleflex Inc.*, 550 U.S. 398 (2007) (holding that “obvious to try” is a valid rationale for an obviousness finding); *see*

also Pfizer, Inc. v. Apotex, Inc., 480 F.3d 1348 (Fed. Cir. 2007) (emphasizing that

“obviousness cannot be avoided simply by a showing of some degree of unpredictability in the art so long as there was a reasonable probability of success”); SOLUS-1003, ¶111.

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

First, as described above, Fabian discloses electrodeposited copper foil surface that can be used for PCB and microelectronics, which is compatible with use in secondary batteries. Such use compatibility of electrodeposited copper foil between the PCB and the secondary batteries was well-known. SOLUS-1011¹², [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]; SOLUS-1003, ¶112.

Second, Fabian discloses Pc values that fall within the claimed range. As described above, Fabian discloses 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

¹² WO2015/102323 to Choi (SOLUS-1010) was published in Korean. Thus, all citations to Choi are to its English translation (SOLUS-1011).

to be effective toward enhancing uniformity or void reduction of copper foil surfaces. Additionally, Fabian discloses 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; SOLUS-1003, ¶113.

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 Pc values to both sides of the electrolytic copper foil in Fabian. SOLUS-1004, [0073], [0074], [0122]; SOLUS-1008, [0005], [0008]; SOLUS-1009, 1:12-18; SOLUS-1003, ¶114.

At least for the reasons described above, Fabian in view of conventional knowledge alternatively and/or additionally renders obvious the limitation of overall claim 1. *See Ineos*, 783 F.3d at 869, *Titanium Metals*, 778 F.2d at 782; SOLUS-1003, ¶115.

[1h]

As described above, Shinozaki teaches the electrolytic copper foil surface having a 10-point mean roughness Rz of 1.0-5 μm and both surfaces exhibiting similar roughness characteristics. SOLUS-1003, ¶116.

Further, as explained by Dr. Randall and Fabian, “[a] surface profile can have the same surface roughness with a different number of PPC [Pc or Rpc].” SOLUS-1005, 7,8. In other words, a surface profile can have the same Pc value while having a different surface roughness Rz value, unless Rz value is not significantly changed (e.g., to less than 1 μm) so as to significantly affect the number of peaks that cross the upper and lower criteria lines in determining Pc. SOLUS-1003, ¶117.

Accordingly, Rz of 1.0-5 μm partially overlaps with claimed range of “2 μm or less.” Further, the ’689 Patent provides no indication of criticality or unexpected results associated with the claimed range of Rz. Thus, the partially overlapping range of Rz of 1.0-5 μm presents a *prima facie* case of obviousness of the claimed range. *See In re Peterson*, 315 F.3d 1325, 1329 (Fed. Cir. 2003) (“A *prima facie* case of obviousness typically exists when the ranges of a claimed composition overlap the ranges disclosed in the prior art”); *In re Geisler*, 116 F.3d 1465, 1469–70 (Fed. Cir. 1997) (“When an applicant seeks to overcome a *prima facie* case of obviousness by showing improved performance in a range that is within or overlaps with a range disclosed in the prior art, the applicant must “show that the [claimed] range is *critical*, generally by showing that the claimed range achieves unexpected results relative to the prior art range,” quoting *In re Woodruff*,

919 F.2d 1575, 1578 (Fed. Cir. 1990) (alteration and emphasis in original));

SOLUS-1003, ¶118.

(ii) Claim 2

[2]

In the combination, Shinozaki renders obvious this limitation. For example, Shinozaki describes that “the copper foil is preferably electrolytic copper foil which has . . . an elongation of 4.0% or more.” SOLUS-1004, [0050], [0051]; SOLUS-1003, ¶119.

Shinozaki Table 2 also lists the elongation of untreated copper foil, ranging from 3.2 % to 8.4 % at room temperature. *Id.*, Table 2. Further, as explained by Dr. Randall, Shinozaki’s roughening treatment of the copper foil surface would likely have had minimal effect on the mechanical properties (e.g., elongation of the copper foil), thus complying with the teachings of Shinozaki. An adverse effect on the elongation of the copper foil at failure would be contrary to the goals of Shinozaki, as Shinozaki focuses on producing a current collector that “does not fracture” and maintains “stable performance . . . for a long period of time.” SOLUS-1004, Abstract, [0029]; SOLUS-1003, ¶120.

(iii) Claim 3

[3]

In the combination, Toshio (or Kim) renders obvious this limitation. SOLUS-1003, ¶121.

For example, the '689 Patent merely describes that “[t]he forming of the protective layer includes immersing the copper layer in an antirust solution containing 0.5 to 1.5g/L of chromium (Cr).” *See* SOLUS-1001, 3:65-67, 9:35-38; SOLUS-1003, ¶122.

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]; SOLUS-1003, ¶123.

(iv) Claim 4

[4]

In the combination, Shinozaki renders obvious this limitation. For example, “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 ,” and 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. SOLUS-1003, ¶¶124-125.

(v) Claim 5

[5]

In the combination, Khatibi renders obvious this limitation. For example, as described above with respect to overview of Khatibi section, Khatibi discloses CTE values that fall within the claimed range. For instance, Khatibi discloses CTE values such as 15.8 ppm/K (corresponding to 15.8 $\mu\text{m}/(\text{m} \cdot ^\circ\text{C})$), 16.9 ppm/K, and 18.39 ppm/K at 25 $^\circ\text{C}$, 100 $^\circ\text{C}$, and 200 $^\circ\text{C}$, respectively, for the electrolytic copper foil having a thickness of 12 μm . See discussion *supra* Part IV.A; see SOLUS-1006, Table 2; SOLUS-1003, ¶126.

Further, for instance, Khatibi discloses CTE values such as 17.1, 18.0, and 19.2 $\mu\text{m}/(\text{m}\cdot^{\circ}\text{C})$ at 25 $^{\circ}\text{C}$, 100 $^{\circ}\text{C}$, and 200 $^{\circ}\text{C}$, respectively, for the electrolytic copper foil having a thickness of 18 μm . SOLUS-1006, Table 2; SOLUS-1003, ¶127.

Accordingly, CTE of 17.1-19.2 $\mu\text{m}/(\text{m}\cdot^{\circ}\text{C})$ partially overlaps with claimed range of “17.3 to 22 $\mu\text{m}/(\text{m}\cdot^{\circ}\text{C})$.” Further, the ’689 Patent provides no indication of criticality or unexpected results associated with the claimed range of CTE. Thus, the partially overlapping range of CTE of 17.1-19.2 $\mu\text{m}/(\text{m}\cdot^{\circ}\text{C})$ presents a *prima facie* case of obviousness of the claimed range. *See In re Peterson*, 315 F.3d 1325, 1329 (Fed. Cir. 2003); SOLUS-1003, ¶128.

(vi) Claim 6

[6pre]

To the extent the preamble is deemed limiting, Shinozaki renders this preamble obvious. For example, Shinozaki describes “a lithium ion secondary battery,” which includes a negative electrode that is “comprised of a negative electrode active material layer formed on the surface of a negative electrode current collector.” SOLUS-1004, [0002]; SOLUS-1003, ¶129.

[6a]

See [1pre]-[1a]; SOLUS-1003, ¶130.

[6b]

Shinozaki describes the active material layer disposed (or “active material which is deposited”) on the surface of the electrolytic copper foil or the current collector. SOLUS-1004, [0040], [0029], [0038]; SOLUS-1003, ¶131.

[6c]

As described above with respect to the discussion of claim 1, Shinozaki in view of Khatibi and Toshio (or Kim) render obvious [6c]. *See* [1a]-[1h]. SOLUS-1003, ¶132.

(vii) Claim 7

[7]

As described above with respect to the discussion of [6b], Shinozaki describes that the active material is “comprised of primary particles of silicon, germanium, or tin.” SOLUS-1004, [0038]; SOLUS-1003, ¶133.

(viii) Claim 8

[8]

As described above with respect to the discussion of [6b], Shinozaki describes that the active material is “comprised of primary particles of silicon.” SOLUS-1004, [0038]; SOLUS-1003, ¶134.

(ix) Claim 9

[9]

In the combination, Shinozaki in view of Kim and Toshio render obvious [9]. SOLUS-1003, ¶135.

First, Shinozaki emphasizes the importance of coating the active material on both the front and back surfaces with uniform thickness, aiming to enhance “adhesion between the active material and the [current] collector” and long-term stability. SOLUS-1004, [0028], [0029]; SOLUS-1003, ¶136.

Second, positioning the active material layer over the copper layer of the current collector was well-known and conventional. SOLUS-1003, ¶137

Lastly, in the combination, because most, if not all, current collectors of secondary batteries have their both surfaces coated with active material, it would have been obvious to a POSITA to apply an active material layer on the second protective layer of the second surface (shiny surface), based on Toshio’s and Kim’s teachings of applying or coating the active material layer over the electrolytic copper foil surface with protective layers. *See* SOLUS-1014, claim 1, [0023], [0074], [0092]-[0093]; SOLUS-1012, [0006], [0007], [0018], [0024], [0025], [0028], [0034] ; SOLUS-1003, ¶138.

Therefore, Shinozaki in view of Kim and Toshio render obvious [9]. SOLUS-1003, ¶139.

(x) **Claim 10**

[10pre]

To the extent that preamble is limiting, Shinozaki discloses “an electrolytic copper foil for a lithium ion secondary battery.” SOLUS-1004, Abstract; SOLUS-1003, ¶140.

[10a]

Shinozaki discloses “a negative *electrode [anode]* formed by *an electrode for lithium ion secondary battery*,” “a *positive electrode [cathode]*,” and “a nonaqueous *electrolyte*.” SOLUS-1004, [0079]; SOLUS-1003, ¶141.

Moreover, as explained by Dr. Randall, 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]; SOLUS-1003, ¶142.

[10b]

As described above with respect to the discussion of claim 1, Shinozaki in view of Khatibi and Toshio (or Kim) render obvious [10b]. *See* discussion *supra* section [1a]-[1h]; SOLUS-1003, ¶143.

**B. [GROUND 2] – CLAIMS 1-10 ARE OBVIOUS OVER KIM–
KHATIBI–GRIESI**

The sections below provide an introduction to Kim, Khatibi, and Griesi.¹³

Overview of Kim

As described above with respect to the discussion of “Overview of Kim” section in Ground 1, Kim describes a current collector for use in secondary batteries. SOLUS-1012, Abstract; *See* discussion *supra* Part IV.A; SOLUS-1003, ¶144.

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. SOLUS-1012, Abstract, [0010], [0026]; *See* discussion *supra* Part IV.A; SOLUS-1003, ¶145.

Kim further describes that using a protective layer including a chromate layer provides advantages including corrosion prevention. SOLUS-1012, [0007], [0024], [0025], [0028]; *See* discussion *supra* Part IV.A; SOLUS-1003, ¶145.

Overview of Khatibi

As described above with respect to the discussion of “Overview of Khatibi” section in Ground 1, Khatibi describes a study that investigates the characteristics

¹³ Petitioner incorporates this discussion into Ground 2.

of the coefficient of thermal expansion (CTE) of electrodeposited copper foils and rolled copper foils with thicknesses ranging from 12 μ m to 200 μ m. SOLUS-1006, Abstract; *See* discussion *supra* Part IV.A; SOLUS-1003, ¶146.

Khatibi describes that “[t]he aim of present study was to outline the impact of manufacturing process of thin copper foils on the temperature dependency of E and CTE up to 200°C and investigate the correlation between their properties in this temperature range.” SOLUS-1006, 2; SOLUS-1003, ¶147.

As part of the results of Khatibi’s study, Khatibi shows CTE for electrodeposited copper foils as a function of test temperature. SOLUS-1006, 4, Table 2 (annotated, reproduced below). In Table 2, electrolytic copper foil is designated as DF. *Id.*, 2 (“electrodeposited foil (ED) designated as DF with thicknesses of 12, 18, 35 μ m and 200 μ m were provided by Gould electronics”); SOLUS-1003, ¶148.

Table 2: Results of E and CTE measurements for rolled and electrodeposited Cu foils as a function of test temperature

Designation	CTE(ppm/K)			E(GPa)		
	RT	100°C	200°C	RT	100°C	200°C
12µm-TPC-none	16,6	17,9	19,6	101		
18µm-TPC-none	14,8	20,3	27,6	100		
35µm-TPC-none	15,7	18,1	21,3	101		
12µm-TPC-300°C-30min	16,3	17,1	18,2	108	90	82
18µm-TPC-300°C-30min	17,1	18,1	19,7	101	84	77
35µm-TPC-300°C-30min	14,9	16,5	18,7	101	83	74
12µm-TPC-900°C-30min	15,5	17,2	19,5	87	75	68
18µm-TPC-900°C-30min	17,2	18,2	19,6	74	74	68
35µm-TPC-900°C-30min	14,3	17,1	20,9	79	61	68
12µm-DF-300°C-30min				111	98	69
18µm-DF-300°C-30min				93	87	67
35µm-DF-300°C-30min				96	79	58
12µm-DF-900°C-30min	15,8	16,9	18,39	105	84	68
18µm-DF-900°C-30min	17,1	18,0	19,2	86	77	58
35µm-DF-900°C-30min	16,9	17,4	18,1	90	69	61
200µm-DF-300°C-30min	16,7	16,8	16,9	120	106	91
Bulk copper	16,6	17,4	18,0	93	96	86

SOLUS-1006, Table 2

Accordingly, Khatibi discloses the characteristics of CTE of electrodeposited copper foils as a function of temperature and thickness. SOLUS-1003, ¶149.

Overview of Griesi

Griesi proposes a method for accurately measuring the geometric properties of the copper foil's surface such that an estimation model (so-called "snowball

model”) can be used to estimate the impact of copper foil surface roughness on conductor loss. SOLUS-1015, Abstract; SOLUS-1003, ¶150.

Griesi describes that PCB can utilize a treated electrolytic copper foil and 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, 11 (“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); SOLUS-1003, ¶151.

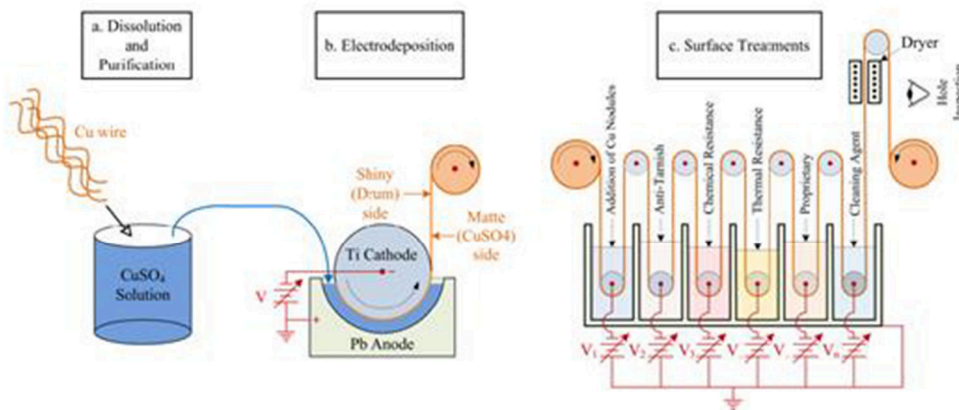


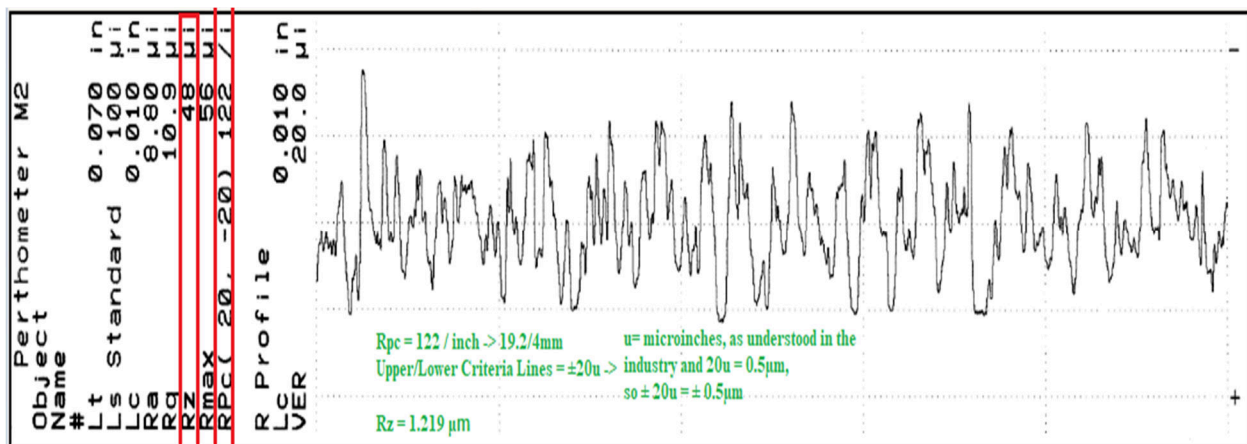
Figure 2.7 Three phases of ED copper foil fabrication. [9]

SOLUS-1015, FIG. 2.7

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.” SOLUS-1015, 27-28; SOLUS-1003, ¶152.

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. SOLUS-1015, 31; SOLUS-1003, ¶153.

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.” SOLUS-1015, 51-52. Griesi shows an example measurement of the surface of untreated copper foil, as described in below reproduced figure 3.16 of Griesi with annotations. *See id.*, 53-54, FIG. 3.16 or SOLUS-1026, 18-19 (annotated, reproduced below); SOLUS-1003, ¶154.



SOLUS-1015; SOLUS-1026, 18-19

As described in the above figure 3.16 of Griesi with annotations and confirmed by Dr. Randall, Griesi's untreated electrolytic copper foil surface shows surface roughness parameter values including $R_z = 1.129 \mu\text{m}$ (e.g., $48 \mu\text{in}$) and P_c (or 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 $-0.5 \mu\text{m}$)). SOLUS-1003, ¶155.

Reasons for combining Kim and Griesi

As an initial matter and explained by Dr. Randall, it was well-known that *untreated* electrolytic copper foil could be effectively and reliably used for both the PCB and secondary battery collector. For instance, numerous prior art disclose such compatibility and reliability. SOLUS-1008, Abstract, [0014], [0066], [0001]; SOLUS-1004, [0003]; SOLUS-1030, [0025], [0043], [0104], [0107], [0108]; SOLUS-1031, [0038], [0052]; SOLUS-1003, ¶156.

Further, Kim teaches that the electrolytic copper foil (e.g., *untreated* or *treated* copper foil) having R_z less than $2 \mu\text{m}$ is advantageous toward battery efficiency and performance. SOLUS-1012, claim 2, [0013], [0025], [0027]; SOLUS-1003, ¶157.

Similarly, Griesi describes the [1] *untreated* electrolytic copper foil for use in PCB (and thus compatible with secondary batteries) and [2] R_z value that is less

than 2 μm . For instance, above reproduced figure 3.16 of Griesi with annotations describe Rz value of 1.2 μm . SOLUS-1015, 53-54; SOLUS-1003, ¶158.

Accordingly, based on the teachings of Kim and well-known knowledge set forth above, a POSITA looking to further optimize Kim'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 recognized the similarities between Kim's and Griesi's copper foil surfaces. Dr. Randall explains that 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 Kim's copper foil surface, for example, to prevent wrinkles or achieve other advantageous effects. SOLUS-1003, ¶159.

In fact, R_{pc} (corresponding to P_c) was a generally known spacing parameter that could be controlled to obtain better bonding finishes and a more uniform finish of the electrolytic copper foil surface. SOLUS-1016, 7; SOLUS-1003, ¶160.

Further, prior art indicates that R_{pc} or P_c 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).[1g]; SOLUS-1003, ¶161.

Accordingly, it would have been “normal desire of scientists or artisans to improve upon what is already generally known.” *Pfizer, Inc. v. Apotex, Inc.*, 480 F. 3d 1348, 1368 (Fed. Cir. 2007).

Therefore, in the combination, based on disclosure of Kim and Griesi in view of common and prior knowledge, it would have been obvious for a POSITA to optimize Pc (or Rpc) through routine experimentation to arrive at the claimed range of Pc. *See KSR International Co.*, 550 U.S. 398 (2007); SOLUS-1003, ¶¶162-163.

Further, a POSITA would have expected success in optimizing the Pc through routine experimentation, at least for the reasons described above with respect to discussion of claim limitation [1g] in Ground 1. *See discussion supra* Part IV.A.1.(i).[1g]; *Pfizer, Inc.*, 480 F.3d 1348 (Fed. Cir. 2007). For instance, as explained by Dr. Randall and prior art, the optimization of Pc (or Rpc) would have involved mere routine adjustments of electrolysis conditions, such as varying concentrations of additives, treatment time, and current density. *See discussion supra* Part IV.A.1.(i).[1g]; SOLUS-1003, ¶164.

Additionally, prior art and generally known knowledge suggest that achieving values within the claimed range (Pc of 3-92) would be straightforward. SOLUS-1003, ¶164. The viability and possibility of such values are evidenced at

least by Griesi and Fabian (e.g., $P_c = 19.2$ in Griesi, P_c of 33.1, 33.3 in Fabian).

See id; see SOLUS-1015, FIG. 3.16; SOLUS-1003, ¶¶164-165.

Notes about Khatibi in the Kim/Griesi combination

As described above, Khatibi discloses the characteristics of the CTE of electrodeposited copper foils as a function of temperature and thickness. In particular, Khatibi provides CTE values for copper foil thickness ranging from 12-200 μm as a function of temperature. SOLUS-1003, ¶166.

In the combination, Kim discloses a copper foil having a thickness ranging from “1 to 35 μm .” SOLUS-1012, [0029]; SOLUS-1003, ¶166.

Accordingly, because Khatibi discloses the characteristics of the CTE of electrolytic copper foils having thicknesses overlapping and similar to those of Kim’s electrolytic copper foils, Khatibi is a relevant disclosure that can relate to the CTE of Kim’s electrolytic copper foils in the combination. SOLUS-1003, ¶167.

1. Analysis

(i) Claim 1

[1pre]

To the extent the preamble is deemed limiting, Kim renders this preamble obvious. For example, Kim specifically discloses a copper foil for the lithium secondary battery, where “the copper foil is made by making an electrodeposited

copper foil by means of electroplating.” SOLUS-1012, [0007]; SOLUS-1003, ¶168.

Kim further discloses the first surface and second surface opposite to the first surface of electrolytic copper foil. For example, Kim describes that a “shiny side is formed on one surface of the electrodeposited copper foil . . . and a matte side having a relatively high surface roughness due to a mountain structure is formed on the other side of the electrodeposited copper foil.” SOLUS-1012, [0007]; SOLUS-1003, ¶169.

[1a]

In the combination, Kim renders obvious [1a]. For example, Kim describes that the “the copper foil is made by making an electrodeposited copper foil by means of electroplating” and “shiny side is formed on one surface of the electrodeposited copper foil . . . and a matte side having a relatively high surface roughness due to a mountain structure is formed on the other side of the electrodeposited copper foil.” SOLUS-1012, [0007]; SOLUS-1003, ¶170.

[1b]-[1c]

In the combination, Kim renders obvious [1b]-[1c]. SOLUS-1003, ¶171.

More specifically, Kim describes that the electrodeposited copper foil having matte side and shiny side is “coated with a protective layer at a post-processing so as to ensure corrosion resistance and color fastness” and is

“generally coated with active material.” SOLUS-1012, [0007], [0018]; SOLUS-1003, ¶172.

Additionally, as explained by Dr. Randall, 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 the same anti-corrosion effect on both surfaces of the copper foil. SOLUS-1003, ¶173.

[1d]

As described above, because Khatibi discloses the characteristics of the CTE of electrolytic copper foils having thicknesses similar to (and overlapping with) those of Kim’s electrolytic copper foils, Khatibi is a relevant disclosure that can relate to the CTE of Kim’s electrolytic copper foils in the combination. *See* discussion *supra* section Overview of Khatibi and section Notes about Khatibi in the Kim/Griesi combination. SOLUS-1003, ¶174.

Further, Khatibi discloses CTE values that fall within the claimed range. For instance, Khatibi discloses CTE values such as 15.8 ppm/K (corresponding to $15.8 \mu\text{m}/(\text{m} \cdot ^\circ\text{C}))$, 16.9 ppm/K, and 18.39 ppm/K at 25 °C, 100 °C, and 200 °C, respectively, for the electrolytic copper foil having a thickness of 12 μm . *See* SOLUS-1006, Table 2 (annotated, reproduced below). Moreover, for instance, Khatibi discloses CTE values such as 17.1 ppm/K, 18.0 ppm/K, and 19.2 ppm/K at

25 °C, 100 °C, and 200 °C, respectively, for the electrolytic copper foil having a thickness of 18 µm. *Id.*; SOLUS-1003, ¶175.

As explained by Dr. Randall, while the claim limitation [1d] recites “measured using a thermomechanical analyzer (TMA),” this is unlikely to significantly impact the CTE value, as variations in equipment and a heating speed of 5°C/min would not significantly alter the results. Further, as Dr. Randall notes: “all of the CTE values for bulk copper are within the claimed range of [1d] as well” meaning that there is nothing special or inventive about the claimed range of CTE for copper of 16 to 22 µm/m·°C. SOLUS-1006, Table 2 (annotated, reproduced below); SOLUS-1035; SOLUS 1036; SOLUS-1003, ¶176.

Table 2: Results of E and CTE measurements for rolled and electrodeposited Cu foils as a function of test temperature

Designation	CTE(ppm/K)			E(GPa)		
	RT	100°C	200°C	RT	100°C	200°C
12µm-TPC-none	16,6	17,9	19,6	101		
18µm-TPC-none	14,8	20,3	27,6	100		
35µm-TPC-none	15,7	18,1	21,3	101		
12µm-TPC-300°C-30min	16,3	17,1	18,2	108	90	82
18µm-TPC-300°C-30min	17,1	18,1	19,7	101	84	77
35µm-TPC-300°C-30min	14,9	16,5	18,7	101	83	74
12µm-TPC-900°C-30min	15,5	17,2	19,5	87	75	68
18µm-TPC-900°C-30min	17,2	18,2	19,6	74	74	68
35µm-TPC-900°C-30min	14,3	17,1	20,9	79	61	68
12µm-DF-300°C-30min				111	98	69
18µm-DF-300°C-30min				93	87	67
35µm-DF-300°C-30min				96	79	58
12µm-DF-900°C-30min	15,8	16,9	18,39	105	84	68
18µm-DF-900°C-30min	17,1	18,0	19,2	86	77	58
35µm-DF-900°C-30min	16,9	17,4	18,1	90	69	61
200µm-DF-300°C-30min	16,7	16,8	16,9	120	106	91
Bulk copper	16,6	17,4	18,0	93	96	86

SOLUS-1006, Table 2

Moreover, “heating the electrolytic copper foil from 30° C. to 190° C. at a speed of 5° C./min” would have produced CTE values similar to Khatibi’s CTE values at 25 °C, 100 °C, and 200 °C, as Khatibi’s temperature range of 25-200 °C is comparable to the 30-190° C range recited in claim 1. SOLUS-1006, Table 2. For example, Dr. Randall explains that “the heating rate (5°C per minute) is typical for certain devices used to measure material expansion, such as a TMA (Thermomechanical Analyzer) or a dilatometer. Typically, these devices use ramp rates between 2°C and 20°C per minute, so the ‘5° C./min’ recited in [1d] is common and should not drastically affect the measurement results.” SOLUS-1003, ¶177.

Additionally, Khatibi Table 2 discloses that electrolytic copper foils with thicknesses ranging from 12 µm to 200 µm exhibit CTE values at 25 °C, 100 °C, and 200 °C that fall within the claimed range of 16 to 22 µm/(m·° C). As explained by Dr. Randall, the claimed range of 16 to 22 µm/(m·°C) is quite broad, to the point that the claimed range encompasses copper foils, bulk copper, and many copper alloys, and thus should at least be considered representative of the CTE characteristics of electrolytic copper foil within this thickness and temperature range. SOLUS-1006, Table 2; SOLUS-1003, ¶178.

[1e]

In the combination, Kim renders obvious [1e]. For example, Kim describes that “the copper foil has a tensile strength of 30 to 40 kgf/mm².” SOLUS-1012, [0015], [0029], Abstract, claim 3. Thus, the partially overlapping range of tensile strength of 30-40 kgf/mm² presents a *prima facie* case of obviousness of the claimed range. *See In re Peterson*, 315 F.3d 1325, 1329 (Fed. Cir. 2003); SOLUS-1003, ¶179.

As explained by Dr. Randall, the claimed tensile strength ranging from 21 to 36 kgf/mm² indicates a broad range, and a heating temperature of 190° C for 1 hour would have had insignificant effect on changes on tensile strength. Additionally, this is supported by other prior art (e.g., Sano), where the majority (12 out of 17) of the high temperature (180°C) tensile strength data for the copper foils disclosed fall within the range of 21 to 36 kgf/mm² as well, and the remaining data bracket the claimed range of 21 to 36 kgf/mm² on both the high and the low ends, thereby encompassing the entire claimed range of [1e]. SOLUS-1008, Table; SOLUS-1003, ¶180.

[1f]

In the combination, Kim renders obvious [1f]. For example, Kim describes that “[t]he weight deviation of the copper foil should be 3% or less” and that “[i]f the weight deviation exceeds 3%, property deviations occur at the surface of the

copper foil, which may increase the number of wrinkles and make properties of the current collector irregular.” SOLUS-1012, [0028], Abstract, claim 3; SOLUS-1003, ¶181.

[1g]

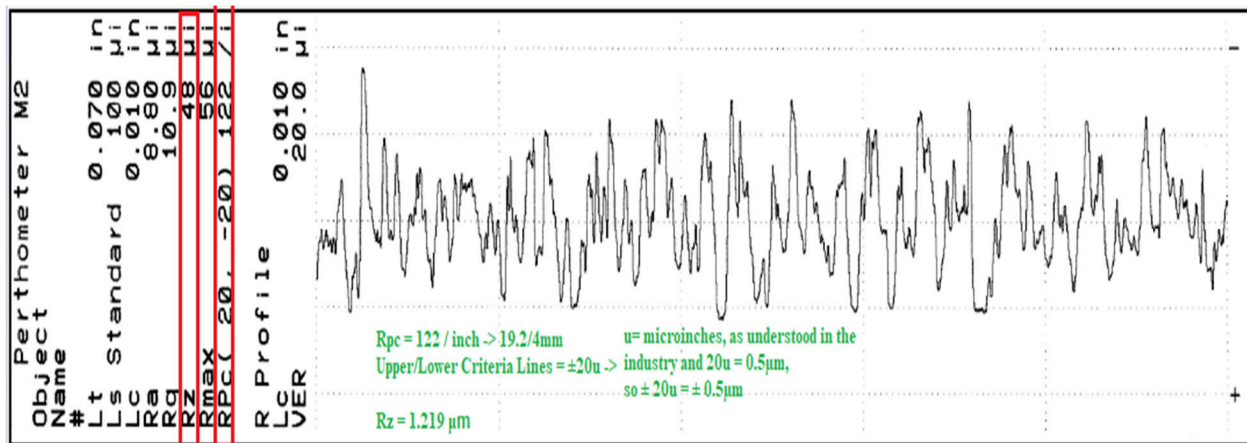
At least for the reasons described below, Kim-Griesi combination renders obvious [1g]. SOLUS-1003, ¶182.

First, as described above with respect to discussion of Ground 1 (Section IV.A.1.), Pc is a recognized measurement shared among different standards and is also equates to Rpc. *See* discussion *supra* Part IV.A.1.(i).[1g]; SOLUS-1003, ¶183.

Second, in the combination, as described above with respect to discussion of reasons for the combination, based on disclosure of Kim and Griesi in view of common and prior knowledge, it would have been obvious for a POSITA to optimize Pc (corresponding to Rpc) of Kim’s electrolytic copper foil surfaces through routine experimentation to arrive at the claimed range of Pc. *See id.*; *see KSR International Co.*, 550 U.S. 398 (2007); SOLUS-1003, ¶184.

Further, a POSITA would have expected success in optimizing the Pc of Kim’s electrolytic copper foil surfaces through routine experimentation, at least for the reasons described above with respect to discussion of claim limitation [1g] in Ground 1. *See* discussion *supra* Part IV.A.1.(i).[1g]; *Pfizer, Inc.*, 480 F.3d 1348

(Fed. Cir. 2007). For instance, as explained by Dr. Randall and as confirmed through various prior art, the optimization of Pc would have involved mere routine adjustments of electrolysis conditions, such as varying concentrations of additives, treatment time, and current density. SOLUS-1003, ¶185. Additionally, prior art and generally known knowledge suggest that achieving values within the claimed range (Pc of 3-92) would be straightforward, in which the *viability and possibility of such values are evidenced at least by Griesi and Fabian* (e.g., *Pc = 19.2* in Griesi, *Pc of 33.1, 33.3* in Fabian). See *id*; see SOLUS-1015, FIG. 3.16 (annotated, reproduced below); SOLUS-1003, ¶¶185, 187.



SOLUS-1015, FIG. 3.16 (annotated)

Alternatively/additionally, this specific Rpc (or Pc) value of 19.2 disclosed in Griesi is a relevant disclosure for the recited range of Pc values. See *Ineos*, 783 F.3d at 869, *Titanium Metals*, 778 F.2d at 782. SOLUS-1003, ¶186.

Third, in the combination, both *shiny and matte surfaces* would have a *peak count (Pc) of 3 to 92*. As explained in prior art, it was “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 secondary batteries to minimize the surface roughness differences between the two surfaces. This would have ensured a uniformity of coating surfaces, prevention of wrinkles, and consistent battery reaction. SOLUS-1012, [0018]; 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 Pc values falling within the claimed range of “3 to 92.” SOLUS-1003, ¶188.

Thus, at least for the reasons set forth above, Kim-Griesi combination renders obvious the electrolytic copper foil having a first surface and a second surface with Pc of “3 to 92.” SOLUS-1003, ¶189.

[1h]

Kim describes that the electrodeposited copper foil having matte side and shiny side “has a surface roughness Rz of 2 μ m or less,” thus rendering obvious [1g]. SOLUS-1012, Abstract, [0007], [0013], [0027], claim 2; *See In re Peterson*, 315 F.3d at 1329; *In re Geisler*, 116 F.3d at 1469–70; SOLUS-1003, ¶190.

Additionally/alternatively, because both shiny and matte surfaces would exhibit similar surface profiles, as described above with respect to [1f], Kim further renders obvious this limitation. SOLUS-1003, ¶191.

(ii) Claim 2

[2]

In the combination, Kim renders obvious this limitation. For example, Kim describes that “the copper foil has . . . elongation of 3 to 20%.” SOLUS-1012, Abstract, [0016], [0029], claim 5; SOLUS-1003, ¶192.

(iii) Claim 3

[3]

In the combination, Kim renders obvious this limitation. For example, the ’689 Patent merely describes that “[t]he forming of the protective layer includes immersing the copper layer in an antirust solution containing 0.5 to 1.5g/L of chromium (Cr).” *See* SOLUS-1001, 3:65-67, 9:35-38; SOLUS-1003, ¶193.

Similarly, in the combination, Kim teaches such protective layer that is applied to the electrolytic copper foil surface. For instance, as described above, Kim teaches applying a protective layer including a *chromate layer* to the electrolytic copper foil surface and describes corresponding advantages including

corrosion prevention. SOLUS-1012, [0007], [0024], [0025], [0028]; SOLUS-1003, ¶194.

(iv) Claim 4

[4]

In the combination, Kim renders obvious this limitation. For example, Kim describes that “the copper foil has . . . thickness of 1 to 35µm.” SOLUS-1012, Abstract, [0017], [0029], Table 1, claim 6; SOLUS-1003, ¶195.

(v) Claim 5

[5]

In the combination, Khatibi renders obvious this limitation. For example, as described above with respect to overview of Khatibi section, Khatibi discloses CTE values that fall within the claimed range. For instance, Khatibi discloses CTE values such as 15.8, 16.9, and 18.39 µm/(m·° C))) at 25, 100, and 200 °C, respectively, for the electrolytic copper foil having a thickness of 12 µm. *See* discussion *supra* Part IV.B; SOLUS-1006, Table 2; SOLUS-1003, ¶196.

Moreover, for instance, Khatibi discloses CTE values such as 17.1, 18.0, and 19.2 µm/(m·° C.) at 25, 100, and 200 °C, respectively, for the electrolytic copper foil having a thickness of 18 µm. *See* SOLUS-1006, Table 2; SOLUS-1003, ¶197.

Accordingly, CTE of 17.1-19.2 $\mu\text{m}/(\text{m}\cdot^{\circ}\text{C})$ partially overlaps with claimed range of “17.3 to 22 $\mu\text{m}/(\text{m}\cdot^{\circ}\text{C})$.” Further, the ’689 Patent provides no indication of criticality or unexpected results associated with the claimed range of CTE.

Thus, the partially overlapping range of CTE of 17.1-19.2 $\mu\text{m}/(\text{m}\cdot^{\circ}\text{C})$ presents a *prima facie* case of obviousness of the claimed range. *See In re Peterson*, 315 F.3d 1325, 1329 (Fed. Cir. 2003); SOLUS-1003, ¶198.

(vi) Claim 6

[6pre]

To the extent the preamble is deemed limiting, Kim renders this preamble obvious. For example, Kim describes that “[i]n 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.” SOLUS-1012, [0007]; SOLUS-1003, ¶199.

[6a]

See [1pre]-[1a]; SOLUS-1003, ¶¶200-201.

[6b]

Kim describes the “active material [layer]” disposed on the surface of the electrolytic copper foil or the current collector. SOLUS-1012, [0006], [0007]; SOLUS-1003, ¶202.

[6c]

As described above with respect to the discussion of claim 1, Kim in view of Khatibi and Griesi render obvious [6c]. *See* discussion *supra* Part IV.B.1.(i).[1a]-[1h]; SOLUS-1003, ¶203.

(vii) Claim 7

[7]

In the combination, Kim describes that “the copper foil is generally coated with active material such as carbon-based slurry,” which conveys that at least one active material is “carbon-based.” SOLUS-1012, [0007]. SOLUS-1003, ¶204.

Additionally/alternatively, as explained by Dr. Randall, it was already disclosed in prior art and also conventional that silicon, germanium, tin, or an alloyed compound thereof could be used as one or more of active materials. SOLUS-1004, [0038]; SOLUS-1003, ¶205.

(viii) Claim 8

[8]

As described above with respect to the discussion of [7], 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]; SOLUS-1003, ¶206.

(ix) Claim 9

[9]

Kim describes that the electrodeposited copper foil having matte side and shiny side is “coated” with active materials. SOLUS-1012, [0006], [0007]; SOLUS-1003, ¶207.

Further, because Kim describes or suggests applying or coating the active material layer over the electrolytic copper foil surface having the protective layers, it would have been obvious to a POSITA to apply an active material layer on the second protective layer of the second surface (shiny surface). *See* SOLUS-1012, [0006], [0007], [0018], [0024], [0025], [0028], [0034]; SOLUS-1003, ¶208.

(x) Claim 10

[10pre]

To the extent the preamble is deemed limiting, Kim renders this preamble obvious. For example, Kim specifically relates to a “copper foil used as a current collector of a lithium secondary battery.” SOLUS-1012, [0003]; SOLUS-1003, ¶209.

[10a]

As explained by Dr. Randall, this limitation relates to a conventional knowledge. SOLUS-1003, ¶210.

For example, as explained in Kim and further confirmed by Dr. Randall, it was conventional [1] for a battery to have both a cathode and an anode (including a secondary battery electrode), as well as 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]; SOLUS-1003, ¶211.

[10b]

As described above with respect to the discussion of claim 1, Kim in view of Khatibi and Griesi render obvious [10b]. *See* discussion *supra* Part IV.B.1.(i).[1a]-[1h]. SOLUS-1003, ¶212.

V. SECONDARY CONSIDERATIONS

Petitioner is unaware of any secondary considerations evidence that would affect, let alone overcome, the strong case of obviousness set forth above. To the extent Patent Owner subsequently presents such evidence, Petitioner respectfully requests the right to respond.

VI. PTAB DISCRETION SHOULD NOT PRECLUDE INSTITUTION

A. The *Fintiv* Factors Favor Institution—§314(a)

The Board should not discretionarily deny because Petitioner's arguments are compelling with substantial supporting evidence, and further because the *Fintiv* factors do not favor denial.

Factor 1 is neutral; neither party has requested a stay in co-pending litigation.

Factor 2 is neutral based on an expected Final Written Decision (FWD) date in March 2026, which is within four months of the currently scheduled trial date of November 3, 2025. *See* SOLUS-1038. Moreover, Solus's Motion to Transfer that was filed on June 12, 2024, if successful, will help ensure that the FWD outpaces any trial date, based on the actual schedule or the median time-to-trial. *See* SOLUS-1039.

Factor 3 favors institution; Petitioner has diligently filed this Petition months ahead of the one-year time bar, while the EDTX litigation is still in its early stages and the parties and the court have yet to expend significant resources on invalidity.

Factor 4 favors institution; if the Board institutes trial, Petitioner stipulates not to seek resolution in the district court of the same grounds presented in this Petition.

Factor 5 is neutral; parties in the parallel litigation are the same.

Factor 6 favors institution; the Petition presents a compelling case of invalidity.

B. The *Advanced Bionics* Test Favors Institution—§ 325(d)

This Petition presents new prior art and arguments against the Challenged Claims for which the file history contains no indication that the Office ever previously considered in connection with the '689 Patent.

VII. CONCLUSION

The Challenged Claims are unpatentable. Petitioner authorizes charge of fees to Deposit Account 06-1050.

VIII. MANDATORY NOTICES UNDER 37 C.F.R. § 42.8(a)(1)

A. Real Party-In-Interest Under 37 C.F.R. § 42.8(b)(1)

Solus Advanced Materials Co., Ltd. is the petitioner, and Volta Energy Solutions Canada Inc., Volta Energy Solutions Europe KFT, Volta Energy Solutions Hungary KFT, and Volta Energy Solutions S.A.R.L. are the Real Parties-In-Interest in this proceeding.

B. Related Matters Under 37 C.F.R. § 42.8(b)(2)

Petitioner is not aware of any disclaimers, reexamination certificates or petitions for inter partes review for the '689 Patent. The '689 Patent is the subject of civil action: *SK nexilis Co., Ltd. v. Solus Advanced Materials Co., Ltd. et al.*, Case 2-23-cv-00539 (EDTX), filed November 21, 2023.

C. Lead And Back-Up Counsel Under 37 C.F.R. § 42.8(b)(3)

Petitioner provides the following designation of counsel.

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D. Service Information

Please address all correspondence and service to the address listed above.

Petitioner consents to electronic service by email at IPR57533-0002IP1@fr.com.

Respectfully submitted,

Dated: September 20, 2024

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CERTIFICATION UNDER 37 CFR § 42.24

Under the provisions of 37 CFR § 42.24(d), the undersigned hereby certifies that the word count for the foregoing Petition for *Inter Partes* Review totals 13,920 words, which is less than the 14,000 allowed under 37 CFR § 42.24.

Dated: September 20, 2024

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CERTIFICATE OF SERVICE

Pursuant to 37 CFR §§ 42.6(e)(4)(i) *et seq.* and 42.105(b), the undersigned certifies that on September 20, 2024, a complete and entire copy of this Petition for *Inter Partes* Review and all supporting exhibits were provided by USPS Priority Express Mail, to the Patent Owner by serving the correspondence address of record as follows:

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