

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent of: Seung Min Kim, et al.
U.S. Patent No.: 11,346,014 Attorney Docket No. 57533-0003IP1
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Appl. Serial No.: 16/643,758
Filing Date: Mar. 31, 2020
Title: ELECTROLYTIC COPPER FOIL, METHOD FOR PRODUCING
SAME, AND HIGH-CAPACITY LI SECONDARY BATTERY
NEGATIVE ELECTRODE INCLUDING SAME

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DECLARATION OF DR. JACK JOSEFOWICZ

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I, Dr. Jack Josefowicz, of Westlake Village, California, declare that

1. I have been retained by Solus Advanced Materials Co., Ltd. (“Petitioner”) in connection with the above-captioned petition for Inter Partes Review (“IPR”) of U.S. Patent No. 11,346,014 to Seung Min Kim, et al. (“the ’014 Patent”). I understand the ’014 Patent is currently assigned to SK Nexilis Co., Ltd. (“Patent Owner”). I have been asked to provide my independent analysis of the ’014 Patent based on the prior art publications cited in this declaration.

2. I have been asked by Petitioner to offer opinions regarding the ’014 Patent, including the unpatentability of claims 1-8 (which I may refer to subsequently as the “Challenged Claims”) in view of certain prior art. This declaration sets forth the opinions I have reached to date regarding these matters.

3. I am being compensated by Petitioner at my standard hourly consulting rate for my time spent on this matter. My compensation is not contingent on the outcome of the IPR or on the substance of my opinions.

4. I have no financial interest in Petitioner or Patent Owner.

I. QUALIFICATIONS AND BACKGROUND INFORMATION

5. I have provided my full background in my attached curriculum vitae (“CV”). (Appendix A). As indicated in my CV, I received a B.Sc. in Mathematics and Physics from Concordia University, Montreal, in Montreal, Quebec, Canada, in 1969. In 1975, I earned my Ph.D. in Physics from the University of Waterloo, in

Waterloo, Ontario, Canada. In 1975, I secured the position of Research Associate at Harvard University in Cambridge, Massachusetts.

6. In my tenure as senior scientist at Hughes Research Laboratories (1984-1996), I designed and innovated new thin film deposition methods and techniques used in semi-conductor device fabrication. I have extensive experience in thin film coating methods (atomic and molecular layer by layer deposition processes; quantum well structures; epitaxial growth and lattice matching) including electron beam deposition of metals, semi-conductors, optical coatings, and insulators. I designed equipment that performed the multi-target sputtering of metals and semi-conductors, thermal evaporation depositions of metals and insulators and semi-conductors, radio frequency (RF) plasma deposition of metals, semi-conductors, and insulators, as well as spin coating techniques in photolithography and electron beam lithography. I have hands on experience in measuring the mechanical properties of thin films and foils to determine stress and strain properties with the intension of minimizing the compressive and tensile stress in the materials.

7. I also have extensive experience in surface science of thin film properties, including optical and electronic applications for light emitting diode (LED) device design, LED light fixture design and optimization, LED Light Engine printed circuit boards (PCB), advanced electronics for LED power supply drivers and controllers, electronic system prediction analysis for reliability, semiconductor

materials and design for high reliability of design in p-n junctions such as LED devices, and lithium-ion battery development for space satellites.

8. During my tenure at Tyco Electronics as Director of Technology and R&D (1996-2008), I headed engineering divisions in 13 manufacturing facilities around the world. My work involved oversight of engineering and development groups working on advanced and high reliability design of PCBs, including metal core heat sink PCBs used as LED light engines and power supply drivers. My technical programs included PCB thin film surface mount finishes, design for solder joint reliability, process manufacturing optimization, design for manufacturability, and automation of complex process manufacturing in facilities at nine Tyco Electronics manufacturing factories, including “best practice,” statistical process control (SPC), and reliability testing.

9. I also was responsible for collaborative engineering development that improved PCB assembly and improved the reliability and strength in solder joints formed during reflow in automated assembly lines. I also served as an active member of IPC PCB surface finishes committees and participated in writing acceptance standards and specifications for surface finishes such as hot air solder level, immersion silver, electroless Ni immersion Au, and organic solderable protective coatings. I was also active in IPC committees that worked on copper electrochemical plating for planar and through-hole plating applications.

10. In 2008, I helped found LED Roadway Lighting (LRL) Limited. As Executive VP of Technology, I led a team of physicists and engineers, including electrical and mechanical engineers, in the invention and development of new globally acclaimed high efficiency and high reliability LED streetlights, including electronics power supply driver, LED control systems including dimming and on/off controls, optics design, and fixture housing design for optimized thermal management. I also directed the qualification of suppliers for all the components that included electronic devices and components, PCB suppliers, die cast and mould design. I led a team in lean manufacturing, as well as design for manufacturing, parts, and system integration in the manufacturing of the new LED lights.

11. I am currently an independent consultant, working in the fields of PCB fabrication processes and design for manufacturability, LED device design, LED lighting, Li-Ion battery design and performance, and aerospace electronic systems. I have served as an expert technologist in finding the root cause for solder joint fractures on PCB surface mount pads. I also have extensive experience in semiconductor electronics, optical materials, electronic micro-devices, and electronic systems design. I have also served as expert witness in cases involving electronic system failures and root cause determination.

12. I have broad experience in designing, engineering, and developing specifications for LED surface mounting, including layout of discrete LEDs,

selection, and design of printed circuit material for LED light engines (including metal core PCBs) and design for surface mounting, the selection and specification of surface-mount pad materials and surface coating. I am a listed inventor of 22 patents, including LED related technology, and am an author of over 50 refereed academic science journal articles, commercial publications, and presentations.

13. I have been retained on behalf of Solus Advanced Materials Co., Ltd. to offer technical opinions relating to the '014 Patent and prior art references relating to its subject matter. I have reviewed the '014 Patent, and relevant excerpts of the prosecution history of the '014 Patent. I have also reviewed the following references:

SOLUS-1001	U.S. Patent No. 11,346,014 (“’014 Patent”)
SOLUS-1002	Excerpt of File History of the '014 Patent
SOLUS-1004	U.S. Patent Application Publication No. 2010/0136434 (“Hanafusa”)
SOLUS-1005	U.S. Patent No. 8,715,836 (“Dobashi”)
SOLUS-1006	U.S. Patent No. 11,142,838 (“Lee”)
SOLUS-1007	U.S. Patent No. 9,209,485 (“Cheng”)
SOLUS-1008	U.S. Patent No. 8,349,518 (“Kim”)
SOLUS-1009	Song, Jenn-Ming et al., <i>Texture and temperature dependence on the mechanical characteristics of copper electrodeposits</i> , Materials Science & Engineering A 559, 655-664 (2013) (“Song”)

- SOLUS-1010 Geometrical Product Specifications (GPS)—Surface texture: Profile method—Terms, definitions and surface texture parameters, JIS B 0601:(2001) (“JIS B 0601 (2001)”)
- SOLUS-1011 Surface Texture (Surface Roughness, Waviness, and Lay), ASME B46.1-2009, August 20, 2010 (“ASME 2009”)
- SOLUS-1012 U.S. Patent No. 4,981,560 (“Kajihara”)
- SOLUS-1013 U.S. Patent Application Publication No. 2012/0205146 (“Oguro”)
- SOLUS-1017 *The ABC’s of Arc Welding*, KOBELCO, available at https://www.kobelco-welding.jp/education-center/abc/ABC_2005-04.html, retrieved on August 22, 2024 (“KOBELCO”)
- SOLUS-1019 Barclay, William R. et al., *Electroplating—A Treatise on the Electro-Deposition of Metals with a Chapter on Metal-Colouring and Bronzing*, London-Edward-Arnold, 1912
- SOLUS-1020 Kim Jongsoo, et al., Effects of Organic Additives on Residual Stress and Surface Roughness of Electroplated Copper for Flexible PCB, *Corrosion Science and Technology*, Vol. 6, No. 4 (2007), pp.154-158
- SOLUS-1021 ISO-6892-1, Metallic materials—Tensile testing—Part 1: Method of test at room temperature, International Standard, 2009
- SOLUS-1022 IPC-TM-650, Test Methods Manual, Tensile Strength and Elongation, In-House Plating, No. 2.4.18.1, 05/04
- SOLUS-1023 Zhu, Jianyu, et al., *Mechanical properties of commercial copper current collector foils*, The Royal Society of Chemistry, 2013
- SOLUS-1024 *SK nexilis Co., Ltd. v. Solus Advanced Materials Co., Ltd. et al.*, Case 2-23-cv-00539 (EDTX), Proposed Scheduling Order

SOLUS-1025 *SK nexilis Co., Ltd. v. Solus Advanced Materials Co., Ltd. et al.*, Case 2-23-cv-00539 (EDTX), Motion to Transfer Venue

II. OVERVIEW OF CONCLUSIONS FORMED

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

- Claims 1, 4, and 8 are obvious over Hanafusa in view of Dobashi;
- Claim 2 is obvious over Hanafusa in view of Dobashi and Cheng;
- Claim 3 is obvious over Hanafusa in view of Dobashi and Kim;
- Claims 5 and 6 are obvious over Hanafusa in view of Dobashi and Lee;
- and
- Claim 7 is obvious over Hanafusa in view of Dobashi and Kajihara.

III. DESCRIPTION OF THE RELEVANT TIMEFRAME AND LEVEL OF ORDINARY SKILL IN THE ART

15. I understand that the '014 Patent claims a priority date of September 1, 2017, which I will also refer to as the "Priority Date." For the purposes of my analysis, and in the absence of any information to the contrary, I have used the September 1, 2017 date as the relevant date for my analysis of the prior art.

16. In my opinion, a person of ordinary skill in the art ("POSITA") relating to the subject matter of the '014 Patent would have had at least an undergraduate degree in materials science, chemical engineering, electrical engineering, or related

field, or equivalent knowledge, training, or experience, with at least two years of experience working on the development of materials or components for electronic devices such as batteries. Additional education, such as a graduate degree, could compensate for less work experience, and additional work experience could compensate for less formal education.

IV. SUMMARY OF THE '014 PATENT

A. Brief Description

17. I have reviewed and will now summarize the '014 Patent. The '014 Patent describes its purported “invention” as an electrolytic copper foil manufactured through an entirely common, conventional, and standard electroplating method— using “a rotary negative electrode drum,” with a current applied between it and “a positive electrode plate” in an “electrolytic solution,” with optimized concentrations of certain additives including compounds of nitrogen, cobalt, and chromate, which are also entirely common, conventional, and standard to the manufacture of electrolytic copper foils. SOLUS-1001, claim 5, 2:45-62. 7:25-8:38.

18. The '014 Patent further describes its purported “invention” as relating to an electrolytic copper foil with “high adhesiveness to a negative electrode material and a low electrical resistance” that “can be provided by controlling the surface properties of the electrolytic copper foil surface.” SOLUS-1001, Abstract. As the

characteristics of the electrolytic copper foil, the '014 Patent introduces ranges for so-called “binding coefficient,” texture coefficient of a (220) plane, weight deviation, and yield strength. *Id.* at cls 1, 2, 3, 4 2:25-45, 3:5-15, 4:53-5:22, 5:35-6:20. In particular, the claims recite that the binding coefficient at either surface of the electrolytic copper foil ranges from 1.5 to 9.4, that an “X-ray diffraction pattern of the copper film” at either surface of the foil measured at the first surface or the second surface shows a texture coefficient of a (220) plane, defined by Mathematical Expression 2 (shown below), is 0.49 to 1.28, and that the foil has a “yield strength of 21 to 49 kgf/mm².” *Id.*

Mathematical Expression 2:

$$TC(220) = \frac{\frac{I(220)}{I_0(220)}}{\frac{1}{n} \sum \frac{I(hkl)}{I_0(hkl)}}$$

“wherein TC(220) is the texture coefficient of the (220) plane, wherein I(hkl) is the XRD diffraction strength of (hkl) crystal plane of the electrolytic copper foil, I₀(hkl) is XRD diffraction strength of (hkl) crystal plane of standard copper powder prescribed by Joint Committee on Powder Diffraction Standards (JCPDS), wherein n is a number of diffraction peaks within 30° to 95° of diffraction angles (2θ), and

wherein the (hkl) crystal plane includes (111), (200), (220), and (311) crystal planes.” SOLUS-1001, claim 2, 5:35-66.

19. As I discuss below, each and every element set forth in the claims were well-known in the art. Importantly, while the claims recite specific ranges of values for these characteristics, the '014 Patent fails to demonstrate, or even suggest, that these ranges are critical to enhancing an electrolytic copper foil with “high adhesiveness to a negative electrode material and a low electrical resistance” that “can be provided by controlling the surface properties of the electrolytic copper foil surface.” SOLUS-1001, Abstract.

20. I have reviewed relevant portions of the file history of the '014 Patent (SOLUS-1002). The '014 Patent issued from U.S. Patent App. No. 16/643,758. The claims that issued in the '014 Patent were allowed after a single office action that only rejected the claims as being indefinite. SOLUS-1002, 374. In particular, the office action identified the claimed variables as not being defined by units or known variables. SOLUS-1002, 374.

21. In response, Patent Owner amended the claims to specify measurement units and/or standard of measurement (e.g., Rp, peak density, attachment of Cr, texture coefficient of a (220) plane). SOLUS-1002, 390-391. The claims were subsequently allowed. In the Notice of Allowance, the Examiner only identified a single prior art reference (KR 2017-0053888) as not teaching the “binding

coefficient” as expressed by claim 1. SOLUS-1002, 479.

V. TECHNICAL BACKGROUND

A. Historical Perspective of Copper Electroplating and Additives

22. The manufacture of electrolytic copper foil as well as the process involved were mature technology long before the Critical Date. Although an exact date for the first application of electroplating to metals is uncertain, it is Giovanni Beccaria who was acknowledged as the father of electroplating and who did the first experiment, depositing metal by discharging a Leyden bottle and using the spark to decompose metal salts in 1772. Next came Luigi Brugnatelli, who in 1803 successfully electroplated a thin layer of gold onto a silver coin. After these accomplishments, electroplating development languished until the beginning of the 20th century when the physics and engineering understanding of electricity allowed for the development of electricity generators that would support scale up of electrochemical plating for technological applications such as batteries, automotive, aircraft and aerospace, home appliances and many other products that benefited from electroplating of metals on large and small surfaces.

23. In the year of 1912, Barclay and Hainsworth co-wrote a book entitled, **“Electroplating.”** SOLUS-1019, cover page. Even though it was early in the 20th century, in chapter 11 on the electroplating of copper, the authors wrote:

“Many years ago Sir J. W. Swan drew attention to the fact that exceedingly minute additions of glue or gelatine to some copper

depositing solutions exercised an important modifying influence on both the conductivity of the solutions and the character of the deposit. In the case of solutions of copper nitrate, for example, which under ordinary circumstances do not give at all a satisfactory deposit of copper, the addition of a very small proportion of glue made it possible to obtain a beautifully smooth, reguline, and coherent deposit of copper at a fairly high rate of deposition.”

“Since that time many operators have made use, to a greater or lesser extent, of what are now generally known as "addition agents " not merely to copper solutions but to those of other metals, as has already been indicated. In this connection, however, electrolytes of copper have been more extensively experimented with than have other metals, as indeed is natural in view of the extensive applications of copper depositing.”

SOLUS-1019 at 248.

24. As such, the efficacy of additives to achieve desirable characteristics of surface roughness, structural features, and strength for metal foils was known as early as 1912. In 1912, it was already clear to Barclay and Hainsworth, as well as other practicing electrochemists, that additive agents have a significant beneficial influence on the resulting deposit of a metal film or foil as it related to surface roughness, structural features and strength. SOLUS-1019 at 168, 208, 248, 249, 250, 251, 259, 307, 313, 320, 327, 333, 336,

25. By 2007, the use of organic additives was revealed as a means of controlling metal foil characteristics. For example, Jongsoo Kim and Heesan Kim published a scientific paper in 2007 in which the use of organic additive agents was shown to control characteristics in metal foils related to surface roughness, surface

morphology, internal stress, and texture coefficient. SOLUS-1020 at 154-158.

26. In their paper, Jongsoo Kim and Heesan Kim use a host of organic additives for copper plating that function as inhibitors, levelers and accelerators. For example, on page 154 in their introduction, it is stated:

“As inhibitors with 100~100,000 molecular weight, polymers including oxygen suppress charge transfer on the electrode surface during plating.1),2) There are polyethylene glycol (PEG), polyethylene oxide (PEO), polypropylene glycol (PPG), gelatin, and so on. The inhibiting action is explained by adsorption of inhibitor-Cl complex with chloride ion1),3)-6) behaving as uniform barrier to suppress charge transfer.1),7) As levelers, organic compounds including nitrogen such as benzotriazole (BTA), janus green B (JGB), and so on also suppress charge transfer on the electrode surface during plating. However, levelers effecting transport in electrolyte are preferentially adsorbed on the sites such as protrusions and corners to prevent formation of protrusion.5),8)-10) As accelerators, the following organic compounds including sulfur promote charge transfer on the electrode surface: 3-mercapto-1-propane sulfonic acid (MPSA), Bis-(3-sodiumsulfopropyl) disulfide (SPS), 3- N,N-dimethylaminodithiocarbamoyl-1-propanesulphonic acid (DPS), etc.”

SOLUS-1020, 154.

27. The paper shows that through use of different organic additives from the list in the above paragraph, both the surface roughness and the texture coefficient would be changed in the electroplated copper films in a controlled manner. For example, using different additives can achieve desired surface roughness characteristics such as Ra and Rz. As clearly shown in Fig. 2 below, the surface roughness would be controlled between about 10 nm and 50 nm in a controllable

way using different additives at different concentrations. SOLUS-1020, 156

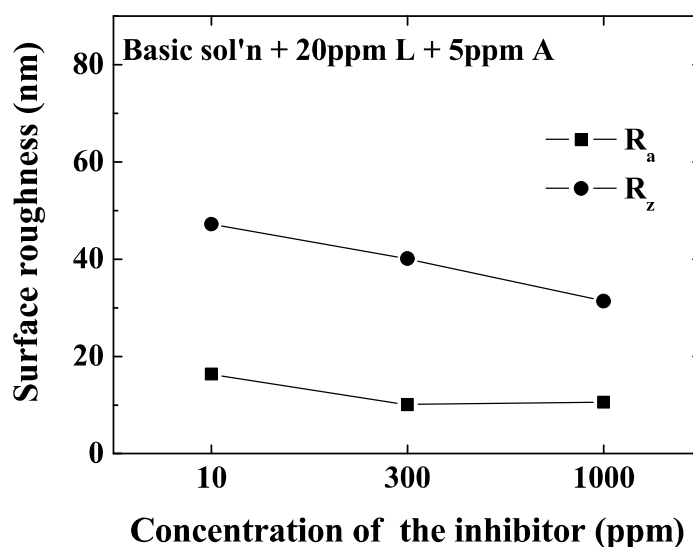


Fig. 2. Surface roughness with the concentration of the inhibitor (I: inhibitor, L: leveler, A: accelerator).

FIG. 2 of SOLUS-1020

28. Additionally, the 2007 paper (SOLUS-1020) shows that texture coefficient may be controlled through use of additives. Table 1 from the publication, shown below, divulges that the addition of accelerator in the plating bath caused the preferred plane to be changed from (220) to (200) as well as decreasing the residual stress. On page 155 of the paper, the definition of texture coefficient is shown below, which is precisely the same definition as used in the '014 Patent:

The texture coefficient, TC of the (hkl) plane is defined by equation (3).

$$TC(hkl) = n \frac{I(hkl)/I_o(hkl)}{\sum I(hkl)/I_o(hkl)} \quad (3)$$

where $I(hkl)$ and $I_o(hkl)$ are the integrated intensities of (hkl) reflections measured for the copper plated film and a standard copper powder sample, respectively and n is the total number of reflection planes.

SOLUS-1020 at 155.

29. Further, Table 1 below shows that, by using different organic additives, significant changes to the texture coefficient and the residual stress can be made:

Table 1. Relation between residual stress and preferred plane formed during plating (I: inhibitor, L: leveler, A: accelerator).

Electrolyte	Texture coefficient			Residual stress (MPa)	Preferred plane
	(111)	(200)	(220)		
300ppm I + 20ppm L	0.23	0.30	2.47	6.92	(220)
300ppm I + 20ppm L + 5ppm A	0.88	1.15	0.97	0	(200)

SOLUS-1020, Table 1.

30. All the discussion above relates to advancements and knowledge gained in the field of electrochemical deposition of copper before the Critical Date. A POSITA would have been familiar with such published results, which demonstrate that all the claims in the '014 Patent that are referred to as inventions already were not novel and fully disclosed in the published domain. A POSITA would have had knowledge that the characteristics, such as texture coefficient, surface roughness, and mechanical properties would be controlled by selecting from organic additive agents as well as inorganic additives when electroplating copper.

B. 0.2% Proof Strength and Yield Strength

31. Based on my knowledge and experience in the field, for certain materials (including electrolytic copper foils) with a smooth stress-strain curve, the curve exhibits no specific point at which the material is considered to begin to strain plastically (irreversibly) under stress. In such cases, the “0.2% proof stress” or the amount of stress needed to force the material to undergo 0.2% plastic (irreversible) deformation is commonly used to define its “yield strength.” SOLUS-1021 at Table K.1, “Yield strength (0.2% proof strengths or upper yield strengths). . .”

32. Therefore, a POSITA would be aware that a copper foil produced using an electrolytic cell with a rolling drum would have a stress-strain curve that is a smooth curve such as the one described in standard ISO 6892-1, Figure 3, which describes the method used to obtain the value of “**0.2% offset yield strength**” or “**0.2% proof stress**.” SOLUS-1021 at 22.

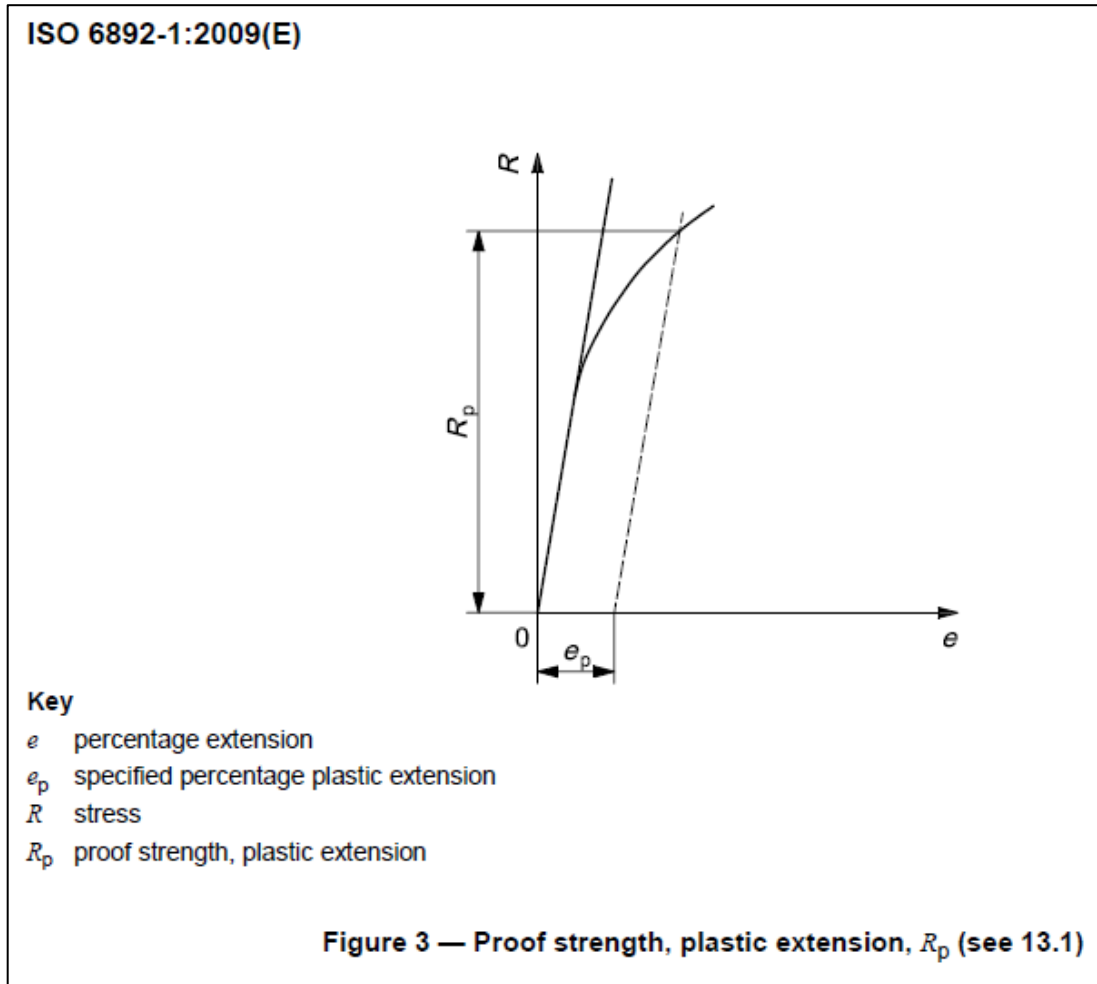


Figure 3 of ISO 6892-1 (SOLUS-1021)

33. International Standard ISO 6892-1 also defines “**yield strength**” as “**0.2% proof strength**” for certain materials. SOLUS-1021 at 58 (emphasis added). As shown below, Table K.1, Annex K of ISO 6892-1 (SOLUS-1021), lists “Yield strength” values of various materials, making it clear that the values are equivalent to “0.2% proof strength.” See SOLUS-1021 at Table K.1 (entitled “Yield strengths (0.2% proof strengths or upper yield strengths). . .”).

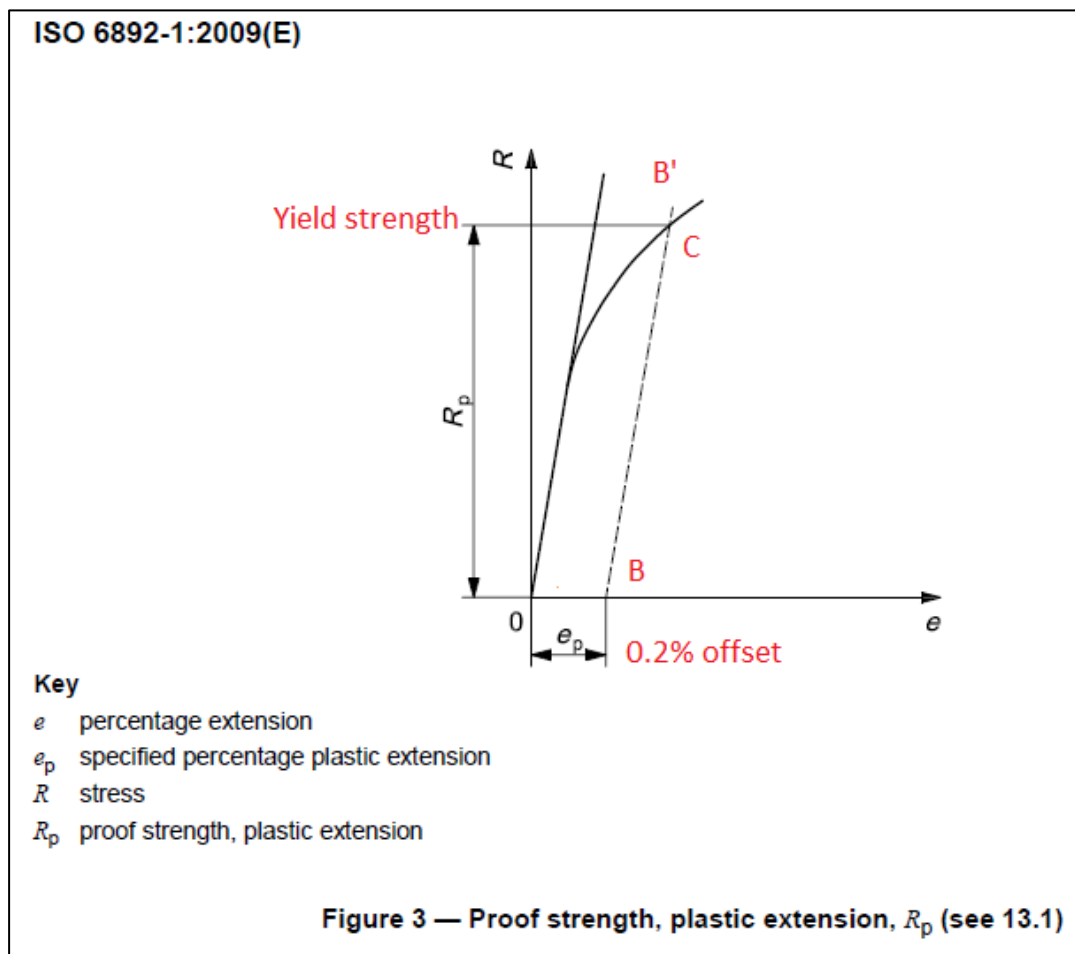
**Table K.1 — Yield strengths (0,2 % proof strengths or upper yield strengths) —
Reproducibility from laboratory intercomparison exercises
(graphic presentation of the values is given in Figure K.1)**

Material	Code	Yield strength MPa	Reproducibility ± %	Reference
Aluminium				
Sheet	AA5754	105,7	3,2	[31]
Sheet	AA5182-O	126,4	1,9	[20]
Sheet	AA6016-T4	127,2	2,2	[20]
	EC-H 19	158,4	4,1	[33]
	2024-T 351	362,9	3,0	[33]
Steel				
Sheet	DX56	162,0	4,6	[31]
Low carbon, plate	HR3	228,6	8,2	[34]
Sheet	ZStE 180	267,1	9,9	[31]
AISI 105	P245GH	367,4	5,0	[34]
	C22	402,4	4,9	[33]
Plate	S355	427,6	6,1	[31]
Austenitic S S	SS316L	230,7	6,9	[31]
Austenitic S S	X2CrNi18-10	303,8	6,5	[34]
Austenitic S S	X2CrNiMo18-10	353,3	7,8	[34]
AISI 316	X5CrNiMo17-12-2	480,1	8,1	[33]
Martensitic S S	X12Cr13	967,5	3,2	[33]
High Strength	30NiCrMo16	1 039,9	2,0	[34]
Nickel alloys				
INCONEL 600	NiCr15Fe8	268,3	4,4	[33]
Nimonic 75	(BCR-661)	298,1	4,0	[29]
Nimonic 75	(BCR-661)	302,1	3,6	[31]

Annotated Table K.1 of SOLUS-1021 (annotated to show listing of “Yield strengths” or “0.2% proof strengths or upper yield strengths”)

34. Based on my knowledge and experience in the field, “**0.2% proof strength**” as defined by ISO 6892-1 (SOLUS-1021) is the equivalent of “0.2% proof stress.” ISO 6892-1, Section 13 was the first edition of the “Metallic materials- Tensile testing, Part 1: Method of test at room temperature” and it standardized the

definition of “**proof strength**” or “ R_p ,” known as the test for “plastic extension.” SOLUS-1021 at 15. “ R_p is determined from the force-extension curve by drawing a line parallel to the linear portion of the curve and at a distance from it equivalent to the prescribed plastic percentage extension, e.g., 0.2 %. The point at which this line intersects the curve gives the force corresponding to the desired proof strength plastic extension. . .” SOLUS-1021 at 15 (emphasis added).



Annotated Figure 3 of SOLUS-1021 (ISO 6892-1) (annotated to show equivalent point ‘C,’ ‘Yield strength,’ or ‘0.2% Proof Strength, and line BB’ parallel to the linear portion of the curve at a distance 0.2% plastic percentage extension)1021 (aSOLUS-())

Annotated Figure 1(b) of SOLUS-1017 (KOBELCO) (annotated to show point ‘C,’ ‘Yield strength,’ line BB,’ and 0.2% offset, equivalent to Annotated Figure 3 of SOLUS-1021 (ISO 6892-1) above)

35. Therefore, “0.2% proof strength” as defined by ISO 6892-1 is the equivalent of “0.2% proof stress” as defined by KOBELCO, and both are referenced as “yield strength,” by KOBELCO and ISO 6892-1. A POSITA would thus have understood that the “yield strength” of an electrolytic copper foil—with a stress-strain curve that “exhibits no such a specific yielding point but produces a smooth curve”—would for practical purposes mean its “**‘0.2% offset yield strength’** or **‘0.2% proof stress’**. . . often referred simply to as **‘yield strength’** or **‘yield stress.’**” SOLUS 1017 at 2.

VI. CLAIM INTERPRETATION

36. I understand that, for purposes of my analysis in this *inter partes* review proceeding, the terms appearing in the patent claims should be interpreted according to their “ordinary and customary meaning.” In determining the ordinary and custom meaning, the words of a claim are first given their plain meaning that those words would have had to a POSITA. I understand that the structure of the claims, the specification, and the file history also may be used to better construe a claim insofar as the plain meaning of the claims cannot be understood. I have followed this approach in my analysis.

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

VII. PRIOR ART ANALYSIS

A. [GROUND 1A] — Claims 1, 4, and 8 are Obvious Over the Hanafusa-Dobashi Combination

38. It is my opinion that a POSITA would have found claims 1, 4, and 8 to be obvious over the combination of Hanafusa and Dobashi, as I discuss in the following sections.

1. Overview of Hanafusa

39. Hanafusa describes electrolytic copper foil for lithium rechargeable batteries and a process for producing such foils. SOLUS-1004 at [0007]. This electrolytic copper foil has “good proof stress and elongation rate and will not be easily broken due to electrode breakage caused by charge and discharge of the lithium rechargeable battery[.]” SOLUS-1004 at Abstract.

40. Hanafusa manufactures its electrolytic copper foil by “subjecting the electrolytic copper foil to an annealing treatment at a specified temperature.”

SOLUS-1004 at [0008]. “Electrode breakage caused by repeated charge and discharge” may be prevented in such electrolytic copper foils when used in a negative current collector for a lithium rechargeable battery. SOLUS-1004 at [0008]. Such electrolytic copper foil would have “sufficient proof stress as an indicator of resistance to breakage and be flexible for expansion and contraction.” SOLUS-1004 at [0010].

41. Hanafusa’s electrolytic copper foil is “continuously manufactured” by “using a rotating metal cathode drum whose surface is polished, and an insoluble metal anode (positive electrode).” SOLUS-1004 at [0016]. Copper is electrodeposited onto the cathode drum by “flowing copper electrolyte between the cathode drum and the anode and applying an electrical potential between them.” SOLUS-1004 at [0016].

42. Hanafusa indicates that surface roughness Rz of the electrolytic copper foil impacts not only the prevention of breakage, but also impacts the “adhesion to a negative-electrode material,” and provides a suitable range for Rz of the electrolytic copper foil. SOLUS-1004 at [0029]. Specifically, Hanafusa states that to prevent breakage, “it is desirable that the surface roughness Rz of the electrolytic copper foil is 2.0 μm or less” and that when surface roughness Rz “is less than 1.0 μm , adhesion to a negative-electrode material tends to decrease.” *Id.* Hanafusa observes that although these are “optimum numerical conditions,” it “should be

realized that **it is possible to manufacture an electrolytic copper foil that meets numerical conditions different**” from those disclosed, **“as the need arises.”** *Id.* at [0030] (emphasis added).

43. It is notable that Hanafusa discloses that in order to prevent cracks “it is necessary to make the rough surface low-profile; however, there is no particular limitation on how to make the rough surface low-profile. **In other words, all the known methods for making a rough surface low-profile can be used.**” SOLUS-1004 at [0023] (emphasis added).

44. Hanafusa also indicates that chromium deposition, though useful to “prevent surface oxidation of the electrolytic copper foil,” may cause “degradation of the charge-discharge property of the lithium battery,” and that therefore “it is necessary to keep the amount of chromium to the minimum.” SOLUS-1004 at [0031]. Hanafusa provides a suitable range for chromium deposition of 2.6 to 4.0 mg/m². *Id.* at [0032]. Hanafusa observes that when “the risk of the surface oxidation is low or can be ignored,” “the rust-proof chromium layer may be used arbitrarily if required.” *Id.* at [0033].

2. Overview of Dobashi

45. At a high level, Dobashi relates to “a surface-treated electro-deposited copper foil” having desirable surface characteristics. SOLUS-1005 at Abstract. Among the surface parameters discussed is “RSm (JIS B 0601, 2001) obtained by

using the stylus-type roughness meter.” *Id.* at 6:24-25. Dobashi describes that RSm is “adopted as the period of waviness” and “used as an indicator for judgment of the surface. The surface has small waviness and is smooth when RSm is large, and the surface has large waviness and is rough when RSm is small.” *Id.* at 6:24-29. Dobashi describes the desirability of performing copper deposition in an electrolytic solution that “preferably comprises at least one selected from MPS [3-mercapto-1-propanesulfonic acid] and SPS [bis(3-sulfopropyl) disulfide],” and that MPS and/or SPS can advantageously cause the matte side of the copper foil to be smooth. *Id.* at 11:60-12:13.

3. The Hanafusa-Dobashi combination

46. In my view, a POSITA would have recognized that Hanafusa’s electrolytic copper foil would be implemented or modified to have the claimed peak density as taught by Dobashi. In particular, the resulting electrolytic copper foil would have an Rz value between 1.0 to 2.0 μm (and therefore an Rp value less than the Rz values, as I discuss in section VII.A.4.(i)[1d] below) and a range for chromium deposition of 2.6 to 4.0 mg/m^2 (as I discuss in section VII.A.4.(i)[1d] below), as taught by Hanafusa, and further have the peak density ranging from 10.3 to 28.6, through Dobashi’s disclosure of RSm values.

47. Moreover, RSm is tightly linked to a peak density. Based on my knowledge and experience in the field, a POSITA would have understood that RSm

is essentially a measure of the average spacing between peaks, or, equivalently, a measure of the average width of ‘profile elements.’ A peak density (or, equivalently, R_{pc} or P_c), on the other hand, tells us how many peaks exist per unit length. That is, R_{Sm} and the peak density contain the same information and the microscopic surface roughness characteristics can be derived from either R_{Sm} or R_{pc} .

48. Accordingly, it is my view that a POSITA would have readily recognized that the R_{Sm} values disclosed by Dobashi are converted into the peak density values that can be compared directly to those of the '014 Patent. I described this in more mathematical detail below in VII.A.4.[1d]. These converted values are utilized and noted with respect to [1d] below.

49. As I demonstrate below, both R_{Sm} and peak density would require the selection of “height discrimination” or “boundary lines” above/below which the surface profile must pass in order to count as a “peak.” Although Dobashi does not explicitly disclose these discrimination lines, whereas the '014 Patent uses discrimination lines of $\pm 0.5 \mu m$ (SOLUS-1001, 14:20-23), the JIS B 0601 (2001) standard, according to which Dobashi’s R_{Sm} is calculated, teaches that, “if not otherwise specified, the default height discrimination shall be 10 % of . . . R_z [.]” SOLUS-1010 at 12. According to that standard, R_z (not to be confused with the ten-point roughness that often shares the same symbol) is the “maximum height of profile.” SOLUS-1010 at 8. Dobashi discloses this parameter as PV, the “maximum

peak to valley height.” SOLUS-1005 at 7:55. Using the disclosed PV, I can put upper limits on the peak density values corresponding to Dobashi’s RSm values, as shown below in section VII.A.4(i)[1d] with respect to the peak density.

50. In my view, several reasons would have motivated a POSITA to implement or modify Hanafusa’s electrolytic copper foil to have the RSm value (and thus the peak density value) as disclosed by Dobashi.

51. For example, a POSITA would have been motivated to apply Dobashi’s disclosure of “RSm” to further achieve Hanafusa’s stated purpose. For example, Hanafusa describes that “it is necessary to make the rough surface low-profile; however, there is no particular limitation on how to make the rough surface low profile. In other words, all the known methods for making a rough surface low-profile can be used.” SOLUS-1005 at [0023]. Therefore a POSITA would have looked into other references like Dobashi to identify such a known method to make a rough surface low-profile. *Id.* Indeed, Dobashi teaches that “RSm can. . . be used as an indicator for judgment of the surface. The surface has small waviness and is smooth when RSm is large.” SOLUS-1005 at 6:25-30.

52. Moreover, a POSITA would have been further motivated to achieve this implementation of the RSm values (and thus peak density values) of Dobashi’s electrolytic copper foil to Hanafusa’s electrolytic copper foil as doing so is merely the application of known techniques (*e.g.*, using additives such as MPS and SPS in

electrolytic solution for the manufacture of electrolytic copper foil with desirable characteristics) to a known structure (*e.g.*, electrolytic copper foil prepared through electrodeposition process) to yield predictable results (*e.g.*, electrolytic copper foil with desirable characteristics including improved surface roughness properties). A POSITA would have expected success in the Hanafusa-Dobashi combination, given that both Hanafusa and Dobashi describe manufacture of electrolytic copper foils with desirable surface roughness properties.

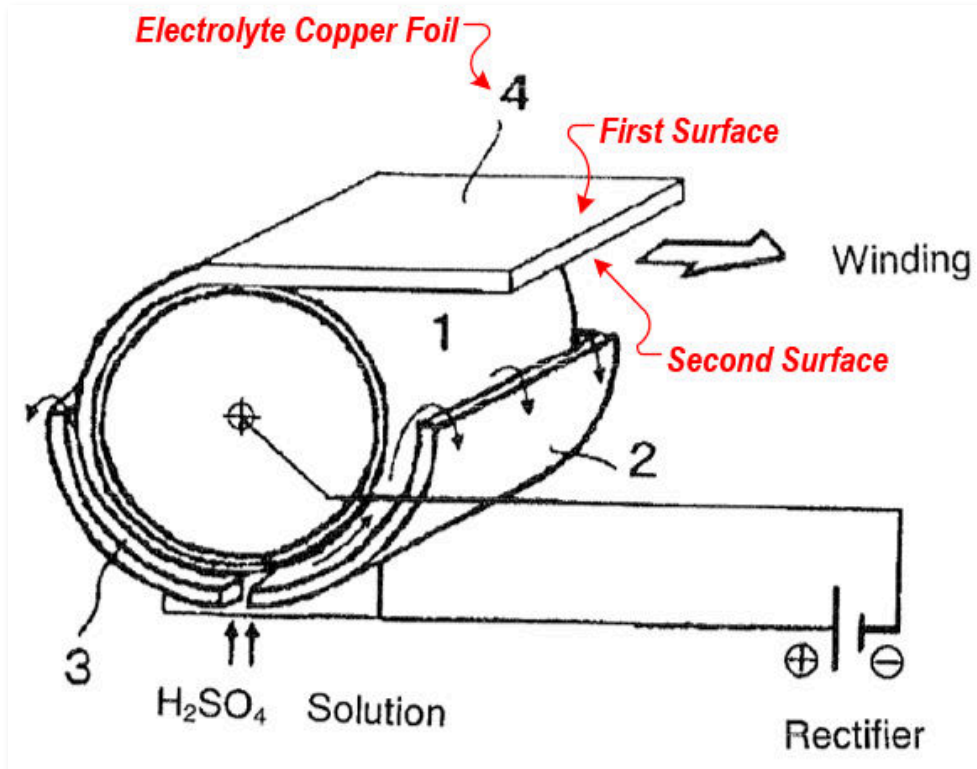
4. Analysis

(i) Claim 1

[1pre] An electrolytic copper foil having a first surface and a second surface, the electrolytic copper foil comprising:

53. As I demonstrate below, to the extent the preamble is deemed to be limiting, Hanafusa discloses [1pre] or Hanafusa-Dobashi renders it obvious. In particular, Hanafusa describes an “electrolytic copper foil for a lithium rechargeable (secondary) battery.” SOLUS-1004 at Abstract. Similar to Hanafusa, Dobashi describes an electro-deposited copper foil. SOLUS-1005 at Abstract.

54. It is my view that the electrolytic copper foil in Hanafusa or Hanafusa-Dobashi has opposing two surfaces corresponding to first and second surfaces, as illustrated in Hanafusa’s Figure 1 below. SOLUS-1004 at [0018].



Annotated Figure 1 of Hanafusa

[1a] a first protective layer at the first surface;

[1b] a second protective layer at the second surface; and

[1c] copper film disposed between the first and second protective layers,
wherein

55. In my view, Hanafusa or Hanafusa-Dobashi renders obvious [1a]-[1c].

56. In particular, Hanafusa's electrolytic copper foil includes a "rust-proof chromium layer" (**protective layer**) on a surface of the electrolytic copper foil. SOLUS-1004 at [0031], cls. 5, 12, 14, 15. Hanafusa recognizes that the electrolytic copper foil needs to be surface-treated "to prevent surface oxidation of the electrolytic copper foil." SOLUS-1004 at [0031]-[0034], [0004], [0013], [0024].

Hanafusa notes that “if the copper foil is left in the atmosphere for a long time, the copper foil will be oxidized and its charge-discharge property tends to degrade.” *Id.* at [0032]. In context of this oxidation phenomenon, Hanafusa specifies that “[t]herefore, the chromium deposition amount should preferably be 2.6 mg/m² or more to obtain the oxidation prevention effect by the rust-proof chromium layer.” *Id.* As such, a POSITA would have readily recognized that Hanafusa’s “rust-proof chromium layer” is a protective layer in that it is a surface treatment layer of the electrolytic copper foil to protect against undesirable phenomenon including oxidation.

57. To the extent that Hanafusa is not explicit as to its “rust-proof chromium layer” being applied to opposite sides of the electrolytic copper foil, a POSITA would have found it obvious to implement Hanafusa’s electrolytic copper foil having protective layers on both sides of the foil. For example, Hanafusa recognizes the need for a “rust-proof chromium layer” (**protective layer**) to be applied “if the surface oxidation tends to easily occur when handling the electrolytic copper foil,” and thus a POSITA would have been motivated and found it obvious to apply such a rust-proof chromium layer to both surfaces (**first and second surfaces**) of the foil because the surface oxidation would naturally occur on both surfaces. SOLUS-1004 at [0033]. It is noted that Hanafusa describes that “it should be realized that the rust-proof chromium layer may be used *arbitrarily if required*.”

SOLUS-1004 at [0033] (emphasis added). Thus, a POSITA would have readily recognized that applying the protective layer to only one of the opposing sides of the copper foil would not achieve the stated goal of Hanafusa (e.g., protect against oxidation).

[1d] a binding coefficient of the electrolytic copper foil at the first surface or the second surface, defined as Mathematical Expression 1 below, is 1.5 to 9.4, (Mathematical Expression 1) Binding coefficient = $R_p/\mu\text{m} + \text{peak density}/30 + \text{amount of attachment of Cr}/(\text{mg}/\text{m}^2)$ (wherein the R_p (μm) is a peak height measured according to JIS B 0601 (2001) standard, wherein the peak density is a number of peaks per unit length of 4 mm, wherein the peak density is measured according to ASME B46.1 (2009) standard with a peak count level of $\pm 0.5 \mu\text{m}$ and wherein the amount of attachment of Cr (mg/m^2) is measured by dissolving the first surface or the second surface of the electrolytic copper foil (110) with a nitric acid solution to obtain a dissolved solution, diluting the dissolved solution with water to obtain a diluted solution, and analyzing the diluted solution using an atomic absorption spectrometer).

58. As I demonstrate below, Hanafusa-Dobashi renders obvious the claimed range of “binding coefficient.” The ’014 patent defines the “binding coefficient” as the function of three independent variables: a peak height (“ R_p ”), a peak density, and an amount of Cr attachment at a surface of the electrolytic copper foil. SOLUS-1001 at cl. 1. The ’014 patent further alleges, without evidence in my view, disadvantages if the “binding coefficient” falls outside the claimed range (1.5-9.4). *Id.*, 5:23-33. Based on my knowledge and experience in the field, however, the term “binding coefficient” as used is not something a POSITA would have recognized and appears to be a value that the authors of the ’014 patent created. Furthermore, in my view the term “binding” implies that the variables in

Mathematical Expression 1 have an effect on binding two surfaces and yet there is no description of a way to measure adhesion, nor does the '014 patent show how the Mathematical Expression 1 was derived as it related to binding. Indeed, the '014 patent is silent as to how the “binding coefficient” was developed or found, nor does it disclose any significance or advantage of using “binding coefficient” in determining the desired binding characteristic of the electrolytic copper foil, as opposed to looking at each of the three parameters that collectively define the value with no association to binding characteristic.

59. Moreover, the claimed range of “binding coefficient” is broad and thus would have been understood by a POSITA to allow for a large range for each of the parameters: R_p , a peak density, and Cr attachment (or average thickness of Cr over the copper foil), which are clearly taught by Hanafusa-Dobashi.

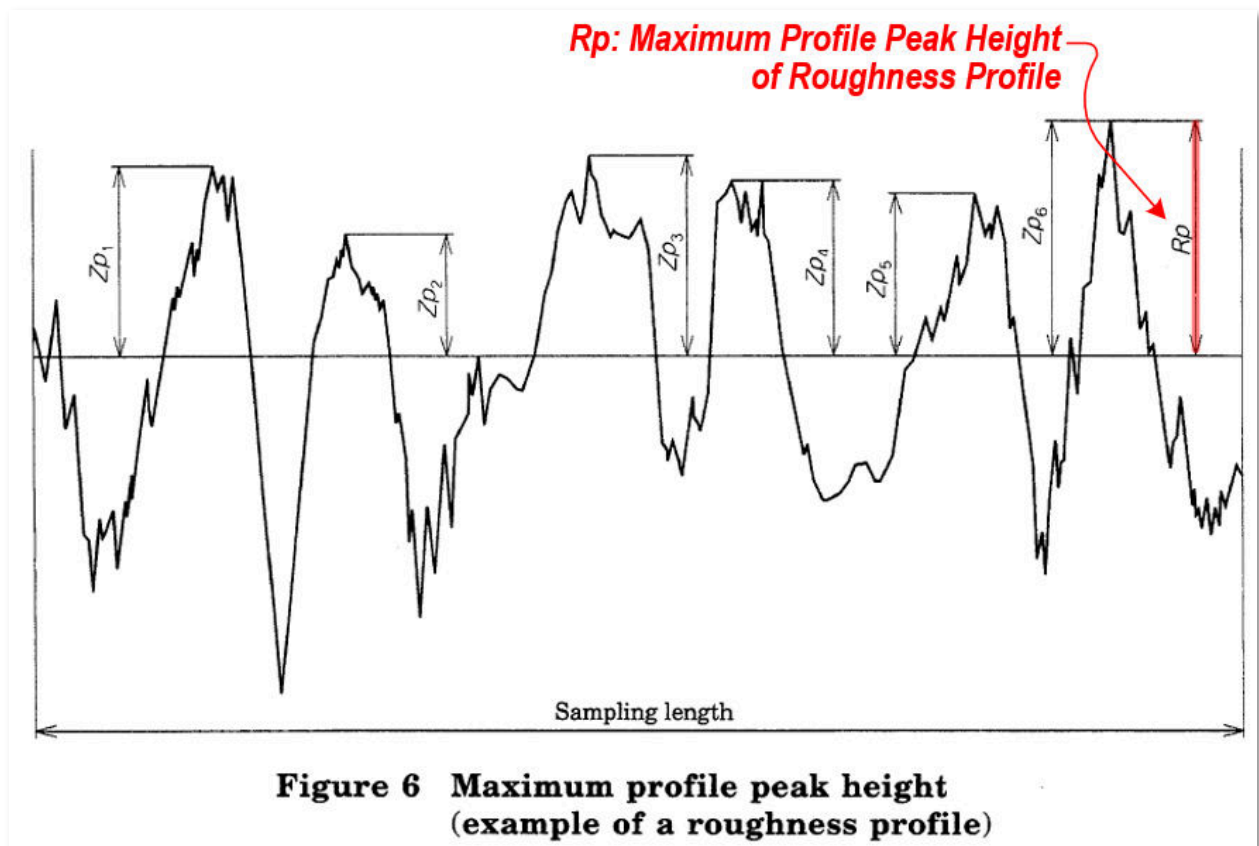
Peak Height (“ R_p ”)

60. As I demonstrate below, in the Hanafusa-Dobashi combination, the “ $R_p/\mu m$ ” value in the “binding coefficient” would be determined to be smaller than the range from 1.0 μm to 2.0 μm as taught by Hanafusa’s surface roughness (R_z) value.

61. In particular, Hanafusa’s “copper foil for a lithium rechargeable battery” has “the surface roughness R_z of the copper foil is 1.0 to 2.0 μm .” SOLUS-1004 at [0012]. Specifically, a POSITA would have understood and found it obvious

that Hanafusa's "surface roughness Rz" relates to, but is greater than, the " $R_p/\mu\text{m}$ "—"a peak height measured according to JIS B 0601 (2001) standard," as required in claim 1. Thus a POSITA would have understood and found it obvious that a value " $R_p/\mu\text{m}$," if measured for Hanafusa's copper foil, must be less than Hanafusa's disclosed maximum Rz value of $2.0\mu\text{m}$.

62. According to JIS B 0601 (2001) standard (as used in the '014 patent), the maximum profile peak height (R_p) is defined as the "maximum profile peak height of roughness profile," illustrated as in Figure 6 (below). SOLUS-1010 at 8-9.

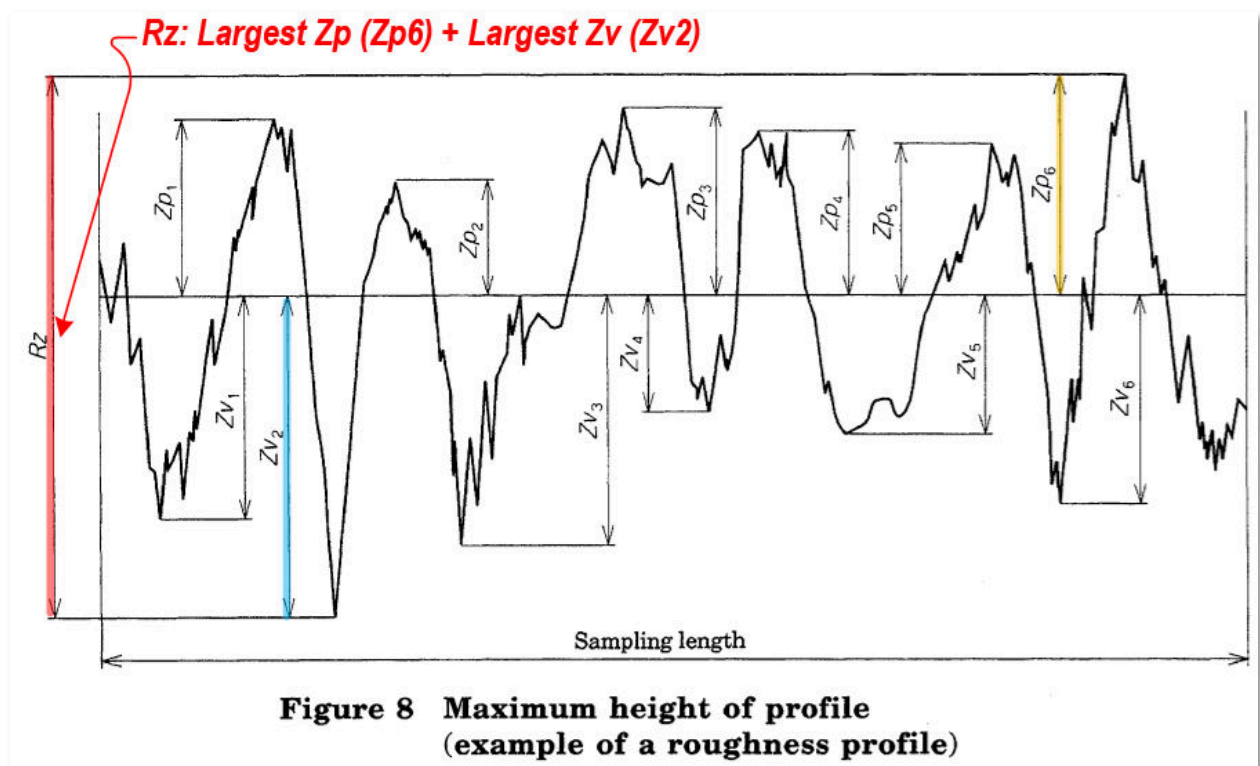


Annotated Figure 6 of SOLUS-1010

63. I note that Hanafusa provides no definition of the surface roughness

(Rz) while describing its particular range. But a POSITA would have understood that Hanafusa's surface roughness (Rz) would be defined according to known standards, and that JIS B 0601 (2001) (as used in the '014 patent) and ASME 2009 were two commonly-used standards for surface roughness measurements around the time of Hanafusa.

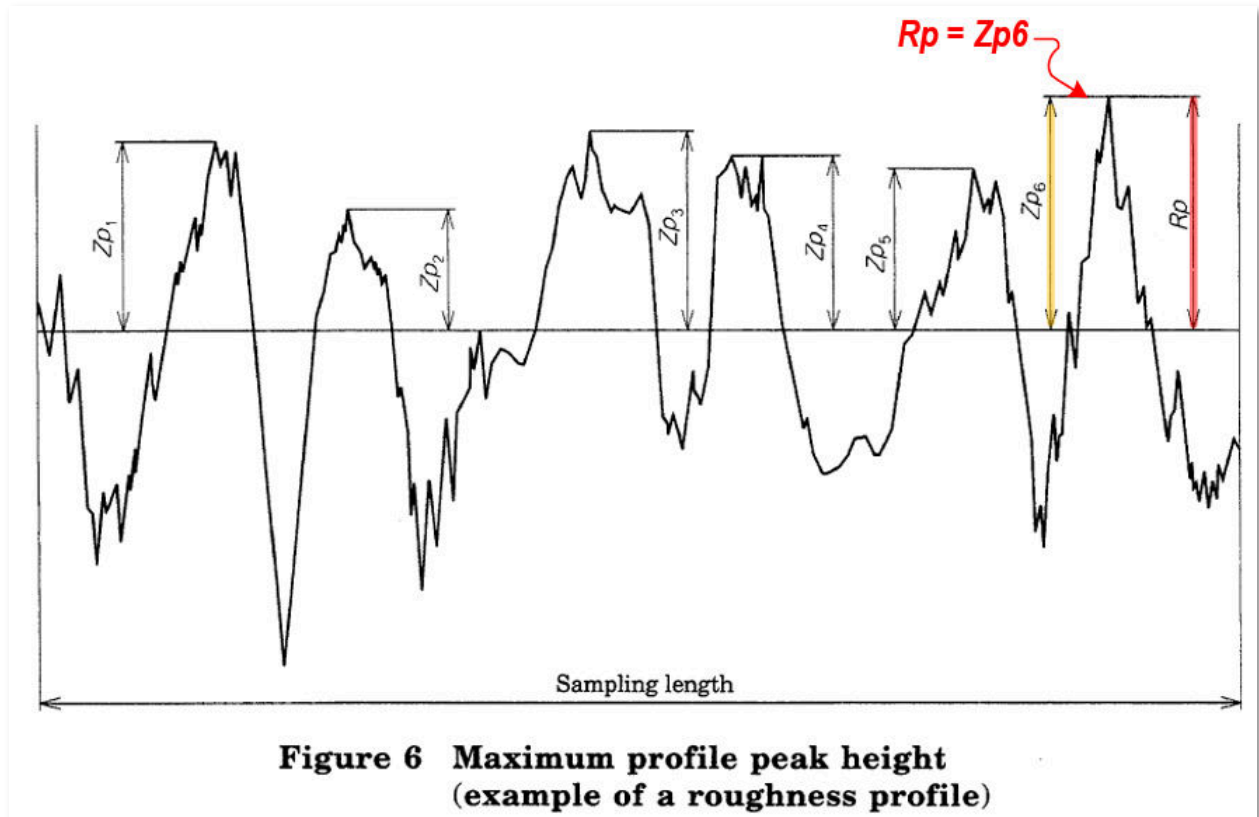
64. First, according to JIS B 0601 (2001) standard, the surface roughness (Rz) is defined as the “sum of height of the largest profile peak height Z_p and the largest profile valley depth Z_v within a sampling length (see Figure 8).” SOLUS-1010 at 8. Therefore, in the example of Figure 8, Rz is the sum of the largest profile peak height (Z_{p6}) and the largest profile peak valley (Z_{v2}).



Annotated Figure 8 of SOLUS-1010

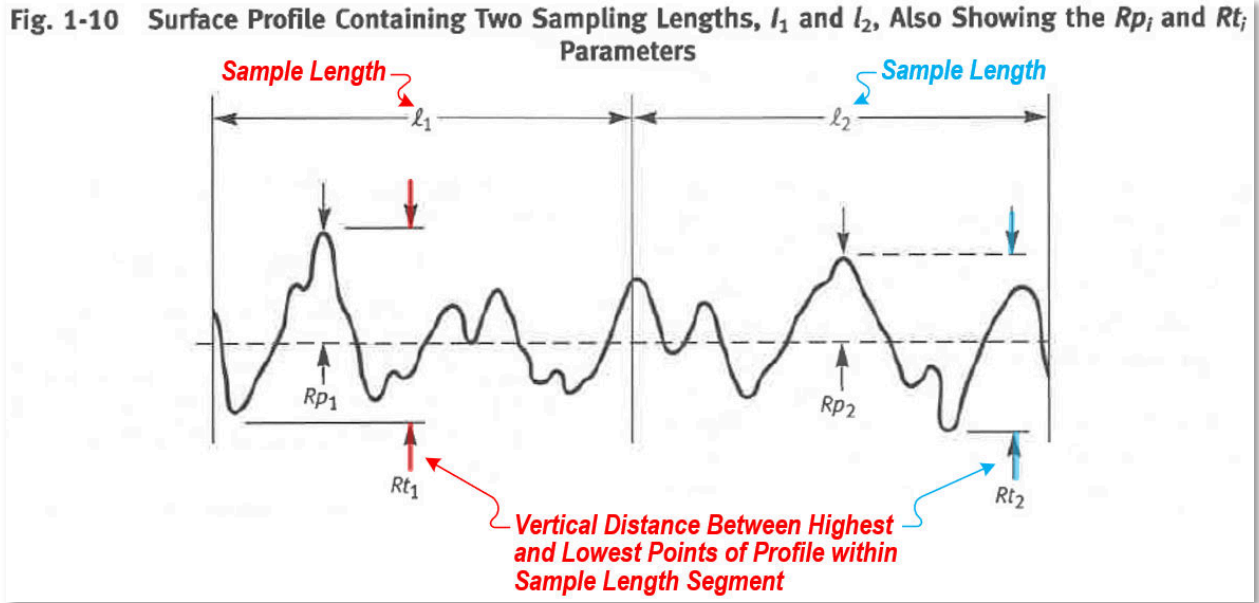
65. Accordingly, a POSITA would have readily understood or otherwise found it obvious that, according to JIS B 0601 (2001) standard, the peak height (R_p), which is the “maximum profile peak height of roughness profile,” is always smaller than the roughness of maximum height (R_z). SOLUS-1010 at 8-9.

66. Referring to Figure 6 below as an example, R_p is the largest profile peak height within the sampling length, which is Z_{p_6} . SOLUS-1010 at 9. Again, under JIS B 0601 (2001) standard, $R_z = Z_{p_6} + Z_{v_2}$ while $R_p = Z_{p_6}$, as illustrated in Figure 8. SOLUS-1010, 10. Therefore, it is my view that by definition, R_p values are always smaller than R_z values taken from the same electrolytic copper foil. As a result, under JIS B 0601 (2001), it would have been obvious to a POSITA that Hanafusa’s copper foil would have R_p that is smaller than R_z ranging from 1.0 to 2.0 μm under JIS B 0601 (2001).



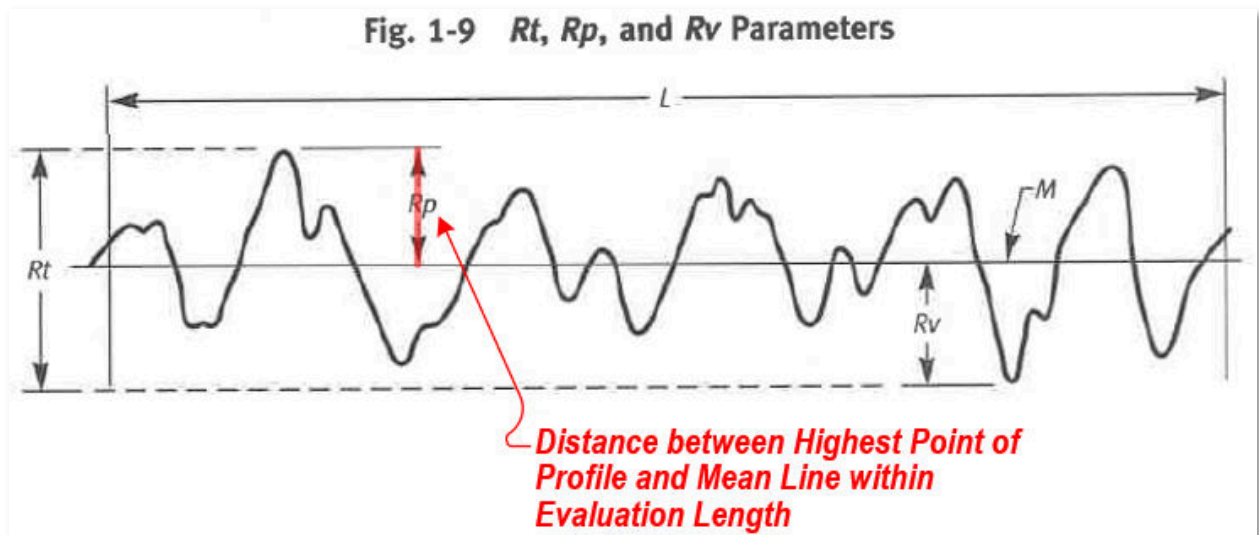
Annotated Figure 6 of SOLUS-1010

67. Second, the other standard, ASME 2009, provides the same outcome, as would have been understood by a POSITA. According to ASME 2009, R_z is defined as “the average of the successive values of R_{t_i} calculated over the evaluation length.” SOLUS-1011 at 8. R_{t_i} is defined as “the vertical distance between the highest and lowest points of the profile within a sampling length segment labeled i (see Fig. 1-10).” SOLUS-1011 at 8, Fig. 1-10 (below).



Annotated Figure 1-10 of SOLUS-1011

68. Further, ASME 2009 defines Rp as “the distance between the highest point of the profile and the mean line within the evaluation length (see Fig. 1-9).” SOLUS-1011 at 8. This is illustrated in Fig. 1-9 (below).



Annotated Fig. 1-9 of SOLUS-1011

69. As such, ASME 2009 defines Rp as the highest peak while Rz is defined as the sum of the highest peak and lowest valley. SOLUS-1011 at 8. As a POSITA would have understood, this is the same as JIS B 0601 (2001) and thus, by definition, Rp values are always smaller than Rz values taken from the same electrolytic copper foil.

70. Accordingly, even under ASME 2009, a POSITA would have found it obvious that Hanafusa's copper foil would have Rp that is smaller than the disclosed Rz values ranging from 1.0 to 2.0 μm .

Peak Density

71. As I demonstrate below, the Hanafusa-Dobashi foil would have a peak density, which contributes to the claimed binding coefficient, through the RSm values disclosed by Dobashi. In particular, the foil in Hanafusa-Dobashi would have a peak density of 10.3 to 28.6.

72. First, as I note above in Section VII.A.3., a POSITA would have found it obvious to perform a straightforward calculation to convert Dobashi's matte side (deposit side) RSm into a matte side peak density. RSm, as disclosed in Dobashi under JIS B 0601, 2001, is defined as the "mean value of the profile element widths X_s within a sampling length" and is mathematically defined as:

$$\text{RSm} = \frac{1}{m} \sum_{i=1}^m X_{si}$$

SOLUS-1010 at 12, Figure 10 (below).

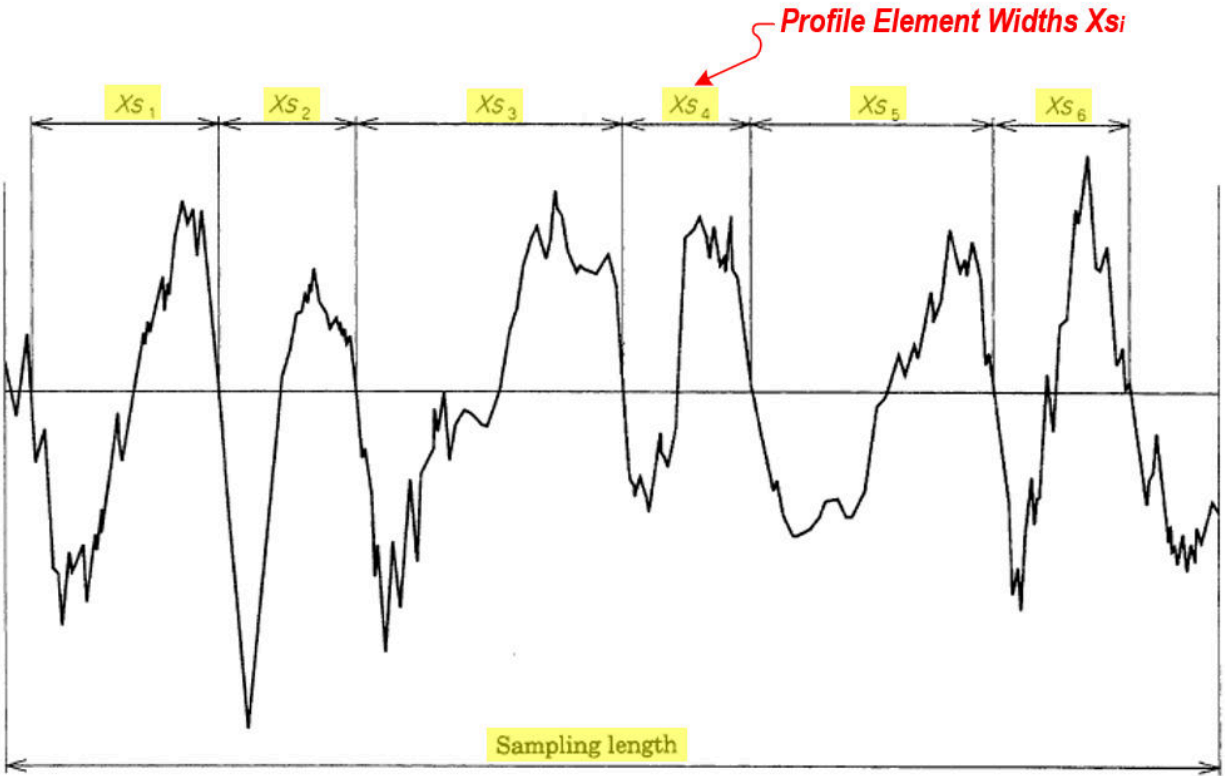


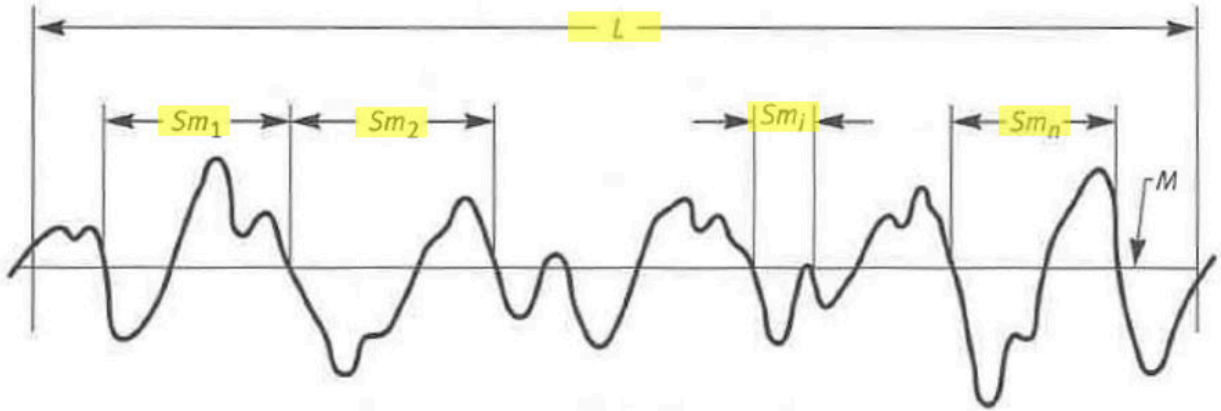
Figure 10 Width of profile elements

Annotated Figure 10 of JIS 0601, 2001(SOLUS-1010)

73. Here, RS_m under the ASME B46.1 (2009) standard, which governs claim 1 peak density and therefore governs closely related RS_m , is defined identically to JIS 0601, 2001 as “the mean value of the spacing between profile irregularities within the evaluation length” and is mathematically defined as:

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

SOLUS-1011 at 9, Fig. 1-13 (below).



Annotated Fig. 1-13 (“The Mean Spacing of Profile Irregularities, RSm”) of
ASME B46.1 (SOLUS-1011)

74. Thus a POSITA would have understood RSm, according to either JIS 0601, 2001 or ASME B46.1, as the average lateral distance or spacing between individual peaks in a given sampling length.

75. Given an RSm value (e.g., the average lateral distance or spacing between individual peaks) and a sampling/evaluation length (e.g., a unit length of 4 mm, as given in claim 1), a POSITA would have calculated a peak density of any electrolytic copper foil by dividing the sampling/evaluation length by the spacing between peaks. This is consistent with the '014 patent's disclosure that defines a peak density as “a number of peaks per unit length of 4 mm, wherein the peak density is measured according to ASME B46.1 (2009) standard with a peak count level of $\pm 0.5 \mu\text{m}[\cdot]$ ” SOLUS-1001 at cl. 1. Simply put, the number of peaks in a given sampling/evaluation length of copper foil would be calculated by dividing that sampling/evaluation length by the length, on average, between each of the peaks, or

the spacing between peaks.

76. As such, I calculate peak density based on RSm as follows:

$$\begin{aligned}\text{Peak density} &= \text{Unit Length (sampling/evaluation length)} \\ &\div \text{RSm (spacing between peaks)} \\ &= 4 \text{ mm} / \text{RSm}\end{aligned}$$

77. By way of example, where the RSm value of Dobashi TABLE 2, Example 1 (below) is used, I calculate the peak density as follows:

$$\text{Peak density} = 4 \text{ mm} / 0.19 \text{ mm} = 21.1 \text{ peaks per 4 mm}$$

78. Similarly, I show other resulting peak density values in the modified Dobashi Table 2 below. Notably, the resulting peak density values range from 10.3 to 28.6.

TABLE 2

Subject	Copper foil thickness (μm)	Deposit side of electro-deposited copper foil							Deposit Side Peak Density	Default Discrimination Criteria (μm)	
		Three-dimensional surface structure analysis			Stylus-type roughness meter		Gloss Gs				
		Wmax	PV	Wmax/PV	Rzjis	RSm	(60°)				
		(μm)	(μm)	(-)	(μm)	(mm)	TD	MD			
Example 1	15	0.37	0.39	0.949	0.32	0.19	659	665	→	21.1	0.039
Example 2	12	0.45	0.48	0.938	0.31	0.16	664	671	→	25	0.048
Example 3	70	0.065	0.079	0.823	0.17	0.39	691	686	→	10.3	0.0079
Example 4	15	0.27	0.30	0.904	0.29	0.18	790	790	→	22.2	0.03
Example 5	15	0.36	0.39	0.943	0.31	0.16	775	773	→	25	0.039
Example 6	12	0.42	0.44	0.959	0.47	0.22	654	687	→	18.2	0.044
Example 7	12	0.58	0.66	0.869	0.71	0.14	608	640	→	28.6	0.066
Comparative Example	12	0.82	1.87	0.439	1.00	0.07	324	383			

Modified Table 2 of Dobashi

79. I note that Dobashi does not explicitly disclose discrimination lines to be used in RSm, peak density calculations, while the '014 Patent describes using $\pm 0.5 \mu\text{m}$. SOLUS-1001 at 14:20-23. However, as I discuss in Section VII.A.3. above, the JIS 0601 (2001) standard describes how to determine “default” discrimination criteria using the equivalent of Dobashi’s PV. SOLUS-1010 at 10, 14. The calculated default discrimination criteria using Dobashi PV values are much lower than the $\pm 0.5 \mu\text{m}$ used in the '014 Patent. Assuming that the disclosed RSm were measured according to the cited standard (which would be the most obvious conclusion), it is my view that a POSITA would have understood that the use of the cited standard (resulting in more stringent requirements for what may be counted as a peak) would result in fewer peaks being measured, i.e., a **lower** Peak Density. As such it is my view that a POSITA would have treated the calculated matte side Peak Density as

upper bounds on the matte side Peak Density obtained using the cited standard ± 0.5 μm discrimination lines.

80. I note that, although Dobashi effectively discloses matte side peak density, Dobashi does not explicitly discuss the shiny side peak density. However, even assuming the shiny side peak density has a much higher peak density than that of the matte side such that the shiny side the of the Hanafusa-Dobashi electrolytic copper foil could not plausibly meet the claimed “binding coefficient” limitation range of 1.5 to 9.4, this does not preclude Hanafusa-Dobashi from meeting the limitation. This is because the “binding coefficient” limitation need only be satisfied “at the first surface **or** the second surface,” and not both surfaces. ’014 Patent at claim 1, (emphasis added). The matte-side peak density of the Hanafusa-Dobashi electrolytic copper foil, limited by Dobashi to a peak density of 28.6 or less, would clearly allow the binding coefficient limitation to be met, or at least would not preclude the limitation from being met.

Amount of Cr Attachment

81. As I demonstrate below, Hanafusa-Dobashi would have the amount of attachment of Cr (mg/m^2) that is limited to a ceiling of 2.6 to 4.0 mg/m^2 with no floor. Hanafusa discloses that an amount of deposition of chromium is adjusted to prevent surface oxidation of the electrolytic copper foil without causing degradation of the charge-discharge property of the lithium battery. SOLUS-1004 at [0013].

Hanafusa discloses that “. . . a rust-proof chromium layer is provided on a surface of the electrolytic copper foil” but warns that “an excessive deposition. . . may degrade the charge-discharge property of the lithium battery. Therefore, an optimum deposition. . . of chromium is 2.6 to 4.0 mg/m².” SOLUS-1004 at [0013]. Hanafusa further warns that “[t]herefore, it is necessary to keep the amount of chromium to the minimum” and that “if the risk of the surface oxidation is low or can be ignored, it is not particularly indispensable” and that “the rust-proof chromium layer may be used arbitrarily if required.” *Id.* at [0031]-[0033]. Thus, Hanafusa-Dobashi limits the amount of attachment of Cr (mg/m²) to a ceiling of 2.6 to 4.0 mg/m² and does not disclose its minimum in case the risk of surface oxidation is low or can be ignored.

Binding Coefficient

82. As I demonstrate below, in the Hanafusa-Dobashi combination, the electrolytic copper foil would have the binding coefficient that falls within the claimed range (1.5 to 9.4) based on the peak height, the peak density, and the amount of Cr attachment, as provided by the combination. In particular, a POSITA would have readily understood or otherwise found it obvious, with simple calculation, that the sum of certain ranges of three values provided in Hanafusa-Dobashi falls within the “binding coefficient” requirement in [1d] (“Binding coefficient = $R_p/\mu\text{m} + \text{peak density}/30 + \text{amount of attachment of Cr}/(\text{mg}/\text{m}^2)$ ”).

83. As discussed above, Hanafusa-Dobashi has the following values of

three parameters:

- The peak height is smaller than the range from 1.0 to 2.0 μm ;
- The peak density is smaller than 10.3 to 28.6 peaks per 4 mm; and
- The amount of attachment of Cr has a ceiling of 2.6 to 4.0 mg/m^2 with no floor.

84. As I summarize in Tables 1, 2 below, several values selected from the ranges of these parameters would safely fall with the claimed range (1.5 to 9.4) of the “binding coefficient” of claim 1. By way of example, in Example 1.1 of Table 1, the following calculation results in the binding coefficient of 4.9, which falls within the claimed range:

- Binding coefficient (4.9) = $R_p/\mu\text{m}$ (1.99 μm) + peak density/30 (10.3/30)
+ amount of attachment of Cr/(mg/m^2) (2.6 mg/m^2)

EXAMPLE	$R_p/\mu\text{m}$	Peak Density/30	Cr/(mg/m^2)	Mathematical Expression 1
1.1	1.99	0.3	2.6	4.9
1.2	1.99	0.3	4.0	6.3
1.3	1.99	1.0	2.6	5.5
1.4	1.99	1.0	4.0	6.9

Table 1: binding coefficient values assuming $R_p/\mu\text{m}$ of 1.99 (e.g., $< 2.0 \mu\text{m}$ as disclosed by Hanafusa)

85. I should note here that even assuming peak density values that approach zero (due to the use of the more stringent $\pm 0.5 \mu\text{m}$ discrimination lines, which would disqualify most if not nearly all peaks for peak density purposes), the Hanafusa-

Dobashi electrolytic copper foil would not be precluded from meeting the binding coefficient limitation.

86. By way of example, in Example 2.1 of Table 2, the following calculation results in the binding coefficient of 4.7, which falls within the claimed range:

- Binding coefficient (4.7) = $R_p/\mu\text{m}$ (1.99 μm) + peak density/30 (2.6/30) + amount of attachment of Cr/(mg/m²) (2.6mg/m²)

EXAMPLE	Rp/ μm	Peak Density/30	Cr/(mg/m ²)	Mathematical Expression 1
2.1	1.99	0.1	2.6	4.7
2.2	1.99	0.1	4.0	6.1
2.3	1.99	0.2	2.6	4.8
2.4	1.99	0.2	4.0	6.2

Table 2: binding coefficient values assuming $R_p/\mu\text{m}$ of 1.99 and lower peak density values due to use of $\pm 0.5 \mu\text{m}$ discrimination lines

87. Similarly, I show that other examples in Tables 1 and 2 for the electrolytic copper foil of the Hanafusa-Dobashi combination satisfy the recited range of “binding coefficient” (1.5 to 9.4). These specific “binding coefficient” values in Hanafusa-Dobashi are thus a relevant disclosure for the recited range of “binding coefficient.” Thus, Hanafusa-Dobashi renders obvious through the electrolytic copper foil in the combination a “binding coefficient” of 1.5 to 9.4.

88. Alternatively and additionally, the range of “binding coefficient” values (minimum of 4.9 to maximum of 6.9) for the electrolytic copper foil of the Hanafusa-Dobashi combination overlaps the recited range of “binding coefficient”

(1.5 to 9.4), which, according to my understanding, renders the claimed range obvious. I am informed that a presumption of obviousness applies where a claimed range overlaps with a range disclosed in the prior art, but that this presumption can be overcome if the prior art teaches away from the claimed range, or the claimed range produces new and unexpected results. Here, Hanafusa-Dobashi does not teach away from the claimed range, and, indeed, discloses specific values within the claimed range. In addition, the '014 Patent fails to provide any indication of criticality or unexpected results associated with the claimed range of “binding coefficient.” Thus, the overlapping range of “binding coefficient” values of the electrolytic copper foil of the Hanafusa-Dobashi combination presents a case of obviousness of the claimed range that is not challenged.

(ii) Claim 4

[4] The electrolytic copper foil according to claim 1, wherein the electrolytic copper foil has a yield strength of 21 to 49 kgf/mm² measured at normal temperature.

89. As I demonstrate below, the Hanafusa-Dobashi electrolytic copper foil renders obvious the claimed yield strength, as taught by Hanafusa's proof stress. For example, Hanafusa describes that the foil's “0.2% proof stress is 18 to 25 kgf/mm².” SOLUS-1004 at Abstract, cls 1, 6, [0009], [0013], [0026], [0034], [0045], [0060]. In my view, a POSITA would have readily understood that “0.2% proof stress” corresponds to a yield strength measured at normal temperature, as discussed in

section V.B. above. Further, “the stress required to produce an offset (plastic deformation) amount of 0.2 percent is generally used for the standard strength equivalent to the yield point, which is called ‘**0.2% offset yield strength**’ or ‘**0.2% proof stress**.’ Both yield point and 0.2% offset yield strength are often referred simply to as ‘**yield strength**’ or ‘yield stress.’” SOLUS-1017. Thus, a POSITA would have readily understood that “0.2% proof stress” corresponds to a yield strength measured at normal temperature.

90. In particular, Hanafusa provides several examples of “0.2% proof stress” that fall within the recited range of “yield strength” (21 to 49 kgf/mm²), such as 25.0 (“Example 1”) and 23.2 (“Example 2”). SOLUS-1004 at [0045]. Therefore, these specific “0.2% proof stress” values (the same as “yield strength” that is “measured at normal temperature”) disclosed by Hanafusa-Dobashi are a relevant disclosure for the recited range of yield strength. Thus, Hanafusa-Dobashi renders obvious through the electrolytic copper foil in the combination a yield strength of 21 to 49 kgf/mm².

91. Alternatively and additionally, the ’014 Patent provides no indication of criticality or unexpected results associated with the claimed range of the yield strength (21 to 49 kgf/mm²). Therefore, according to my understanding, Hanafusa’s 0.2% proof stress (from 18 to 25 kgf/mm²), which overlaps the recited range of yield strength (21 to 49 kgf/mm²), presents a case of obviousness of the claimed range.

(iii) Claim 8

[8] The electrolytic copper foil according to claim 1, further comprising: negative electrode active material layers on the first surface and the second surface.

92. As I demonstrate below, Hanafusa-Dobashi renders obvious negative electrode active material layers on both surfaces of the foil. In particular, Hanafusa contemplates that “negative-electrode material” should be applied “uniformly on both sides of the copper foil.” SOLUS-1004 at [0061]. Indeed, Hanafusa adjusts its surface roughness (Rz) to be equal to or smaller than 2.0 μm to accomplish the uniform application of negative-electrode material on both sides of the foil. *Id.*

93. Based on my knowledge and experience in the field, a POSITA would have understood or found it obvious that Hanafusa’s “negative electrode material” is the “negative electrode *active* material,” of claim 8. In particular, the ’014 patent specification discloses that a “negative electrode active material layer 120 may include a carbon-based active material, such as **graphite** or coke.” SOLUS-1001 at 7: 5-11, (emphasis added). In my view this is consistent with Hanafusa’s negative electrode material, which is described as having “Negative-electrode material (**graphite** or carbon). SOLUS-1004 at [0046] (emphasis added). The ’014 specification further discloses that the “negative electrode active material layer” “may further include a conductive agent and a **binder**,” consistent in my view with Hanafusa’s negative electrode material, which is described as including a “**Binder**

(polyvinylidene fluoride).” SOLUS-1001 at 7:17-18 (emphasis added); SOLUS-1004 at [0046] (emphasis added). Although the ’014 specification further discloses that the “negative electrode active material layer” “**may** include least one metal selected from the group consisting of Si, Ge, Sn, Li, Zn, Mg, Cd, Ce, Ni, and Fe,” **the specification does not require it.** SOLUS-1001 at 7:10-13. As such, Hanafusa’s “negative electrode material,” consisting of graphite or carbon, a binder, and provided as a layer on both sides of the Hanafusa-Dobashi electrolytic copper foil, is the “negative electrode active material” as claimed in claim 8, and in my view renders obvious the claimed negative electrode active material layers on both surfaces of the foil.

B. [GROUND 1B] — Claim 2 is Obvious Over the Hanafusa-Dobashi-Cheng Combination

1. Overview of Cheng

94. Cheng describes “electrolytic copper foil” that is “particularly suitable for the application of a lithium ion secondary battery,” with a “shiny side and a matte side” where, based on the sum of the texture coefficients “of a (111) surface, a (200) surface, a (220) surface and a (311) surface of the electrolytic copper foil,” the “sum of the texture coefficients of the (220) surface and the (311) surface of the electrolytic copper foil is greater than 60%.” SOLUS-1007 at Abstract. The electrolytic copper foil has “completely different crystalline phase structure” such that it is not easy for it “to break or fracture during the charging-discharging cycles”

such that “the life of a battery is thus increased.” SOLUS-1007 at 3:32-40. The electrolytic copper foil has a roughness of the matte side “less than 2 μm , such that the **roughness difference between the shiny side and the matte side is similar**” and thus “particularly suitable to be used. . . for a lithium ion secondary battery.” SOLUS-1007 at 3:26-28 (emphasis added).

95. Cheng notes that “the (220) surface and (311) surface of the electrolytic copper foil of the present invention have promising crystalline phase characteristics, such that the elongation of the electrolytic copper foil can be greater than 14%. It is further discovered that the electrolytic copper foil with these crystalline phase characteristics resolves the problem of not [being] suitable for use in a lithium ion secondary battery caused by the high roughness of traditional products.” SOLUS-1007, 3:16-23. Among other description, Cheng discloses TC(220), Rz (ten-point roughness), tensile strength, and elongation for copper foils manufactured according to various process parameters. SOLUS-1007, Table 3.

96. Based on my review, Cheng’s texture coefficients (TC) correspond to the TC of the ’014 Patent, to within the level of detail provided by the ’014 Patent. Notably, the TC calculation formulas provided in each document are the same, and the same four crystal planes ((111), (200), (220), and (311)) are considered in TC calculation in each document. SOLUS-1001, cl.2, 5:35-64, 10:64-67, 11:1-5; SOLUS-1007, 2:52-54, 7:25.

2. The Hanafusa-Dobashi-Cheng combination

97. Hanafusa describes that due to the manufacturing process, electrolytic copper foil in contact with the cathode drum “becomes a mirror surface, while the other surface becomes a rough surface with asperity.” SOLUS-1004 at [0022]. Hanafusa notes that such “markedly uneven surface may cause cracks” and that therefore “it is necessary to make the rough surface low-profile; however, there is no particular limitation on how to make the rough surface low-profile. **In other words, all the known methods for making a rough surface low-profile can be used.**” SOLUS-1004 at [0023]. (emphasis added). Therefore in my view, a POSITA would have investigated the “known methods,” such as Cheng’s teachings, to implement Hanafusa’s low-profile surface.

98. By looking to apply the “crystalline phase characteristics” teachings of Cheng to Hanafusa, a POSITA would have, in my view, recognized that Hanafusa’s “rough surface with asperity” would be further improved to have a “low-profile” through the teachings of Cheng. The Hanafusa-Dobashi-Cheng combination implements the electrolytic copper foil with the “crystalline phase characteristics” disclosed in Cheng as one such known method for making a rough surface low-profile to ensure that “the roughness difference between the shiny side and the matte side is smaller,” therefore resolving the problem of “high roughness of traditional products.” SOLUS-1007 at 3:20-26.

99. There are several other reasons that would have motivated a POSITA to implement Hanafusa-Dobashi's electrolytic copper foil with the "crystalline phase characteristics" as disclosed in Cheng, including such characteristics where, "based on the total sum of the texture coefficients of a (111) surface, a (200) surface, a (220) surface and a (311) surface" of the electrolytic copper foil, the "sum of the texture coefficients of the (220) surface and the (311) surface" is greater than 60%. SOLUS-1007 at Abstract.

100. For example, a POSITA would have, in my view, understood the benefits of Cheng's crystalline phase characteristics that would be implemented in Hanafusa-Dobashi-Cheng's foil. In particular, Cheng describes that its crystalline phase characteristics in an electrolytic copper foil would offer advantageous surface roughness properties, which implicate battery performance "in a lithium ion secondary battery," by allowing "an M side with a lower roughness." and thus "increase[ing] the cycle life of the battery." SOLUS-1007 at 2:1-11, 43-46. By looking to apply such specific crystalline phase characteristics to Hanafusa-Dobashi, a POSITA would have recognized it as one of "the known methods for making a rough surface low-profile," thus an improvement, since "such a markedly uneven surface may cause cracks." SOLUS-1004, [0023].

101. In Hanafusa-Dobashi's electrolytic copper foil with the specific crystalline phase characteristics of Cheng, "the roughness of both sides of the . . .

foil . . . is low, and the roughness difference between the two sides is extremely small” therefore “it is not easy for the electrolytic copper foil to break or fracture during the charging-discharging cycles and the life of a battery is thus increased.” SOLUS-1007 at 3:32-39. Thus, a POSITA thus would have recognized and implemented such specific crystalline phase characteristics of Cheng in furtherance of Hanafusa, which identically sought to avoid “such markedly uneven surface” which “may cause cracks.” SOLUS-1004, [0023].

102. Further, a POSITA would have been motivated to make this implementation of Cheng’s crystalline phase characteristics of electrolytic copper foil into Hanafusa-Dobashi’s electrolytic copper foil because doing so is merely the application of known techniques (*e.g.*, using additives in copper sulfate electrolyte for the manufacture of electrolytic copper foil with desirable characteristics) to a known structure (*e.g.*, electrolytic copper foil prepared through electrodeposition process) to yield predictable results (*e.g.*, electrolytic copper foil with desirable characteristics including improved surface roughness properties). Moreover, a POSITA would have expected success in the Hanafusa-Dobashi-Cheng combination, given that both Hanafusa-Dobashi and Cheng already describe manufacture of electrolytic copper foils with desirable surface roughness properties to avoid “cracks,” “break or fracture during the charging-discharging cycles” thereby increasing life of a battery. SOLUS-1004 at [0023]; SOLUS-1007 at 3:32-

39.

3. Analysis of Claim 2

103. As I demonstrate below, Hanafusa-Dobashi-Cheng renders obvious claim 2. For example, as I discuss above in section VII.B.2, Hanafusa recognizes the need “to make the rough surface low-profile,” while recognizing that there is “no particular limitation on how to make the rough surface low-profile.” SOLUS-1004 at [0023]. Moreover, the combination based on Cheng renders obvious, in my view, an electrolytic copper foil with specific “crystalline phase characteristics,” such that “the roughness of both sides of the electrolytic copper foil [is] low and the roughness difference between both sides [are] extremely small,” and therefore “not easy for the electrolytic copper foil to break . . . during the charging-discharging cycles.” SOLUS-1007 at 10:27-34.

104. Based on Cheng’s disclosure, a POSITA would have found it obvious to use electrolytic copper foil with a texture coefficient of a (220) plane (as defined by “Mathematical Expression 2” in claim 2) from 0.49 to 1.28. In fact, all Embodiments and Comparative Examples as described in Cheng Table 3 describe texture coefficients of (220) planes ranging from 0.70 to 3.20. SOLUS-1007 at TABLE 3. This range of texture coefficients of (220) planes, as disclosed in Cheng, overlaps considerably with the claimed range of “0.49 to 1.28,” thus renders the claimed range obvious.

105. Based on my review, the texture coefficients for all Embodiments and Comparative Examples as disclosed in Cheng Table 3, including for texture coefficients of the (220) plane, are calculated based on Cheng's "Equation (I)" below, equivalent to "Mathematical Expression 2" of the '014 patent below as applied to the (220) plane, with the calculations considering the same crystal planes considered in the '014 patent including crystal planes (111), (200), (220), and (311). SOLUS-1007 at 7:20-25, cl.1; SOLUS-1001 at cl.2. I note that "Equation (I)" is general, applied by Cheng to find texture coefficients for all considered crystal planes (e.g., (111), (200), (220), and (311)), including for crystal plane (220), while "Mathematical Expression 2" is specific, since applied in the '014 patent to find the texture coefficient for crystal plane (220) only, and not for the other crystal planes. Thus, "Equation (I)" is equivalent to "Mathematical Expression 2" as applied to the crystal plane (220).

$$TC(hkl) = \frac{I(hkl) / I_0(hkl)}{(1/n) \sum I(hkl) / I_0(hkl)} \quad \text{Equation (I)}$$

Equation (I) of Cheng (SOLUS-1007)

$$TC(220) = \frac{\frac{I(220)}{I_0(220)}}{\frac{1}{n} \sum \frac{I(hkl)}{I_0(hkl)}} \quad (\text{Mathematical Expression 2})$$

Mathematical Expression 2 of the '014 patent (SOLUS-1001)

Test results of the characteristics of electrolytic copper foil									
	Embodi- ment 1	Embodi- ment 2	Embodi- ment 3	Embodi- ment 4	Comparative Example 1	Comparative Example 2	Comparative Example 3	Comparative Example 4	Comparative Example 5
Roughness (Rz) difference between S side and M side (μm)	0.17	0.36	0.26	0.14	0.16	0.14	0.14	0.21	0.66
Weight resistivity (Ωg/m ²)	0.154	0.156	0.154	0.155	0.163	0.162	0.160	0.161	0.155
TC (111)	0.23	0.62	0.33	0.32	1.03	0.98	0.91	1.01	0.30
TC (200)	0.23	0.58	0.30	0.33	1.85	1.51	1.66	1.63	0.18
TC (220)	1.04	1.08	1.07	1.06	0.82	0.72	0.77	0.70	3.20
TC (311)	2.50	1.72	2.30	2.29	0.30	0.79	0.66	0.66	0.32
TC (220) + TC (311)/ TC (total)%	89	70	84	84	28	38	36	34	88
Crack on copper foil after charging- discharging test	No	No	No	No	Yes	Yes	Yes	Yes	Yes

Annotated Table 3 of Cheng (annotated to show TC (220) of Embodiments 1,2,3,4 and Comparative Examples 1,2,3,4,5)

106. Specifically, as I show in Cheng Table 3 (reproduced above), Embodiments 1, 2, 3, 4, as well as Comparative Examples 1, 2, 3, 4, fall within the claimed range. Thus, it is my view that a POSITA would have understood that the Hanafusa-Dobashi-Cheng combination has the claimed texture coefficient of 0.49 to 1.28, as taught by Cheng.

107. Additionally, there is no indication in the '014 patent that the claimed

range of texture coefficients of a (220) plane shows “unexpected results relative to the prior art range,” and therefore the ’014 patent fails to show that the claimed range is critical, thus further failing to demonstrate that it is not obvious.

108. It is my view that the ’014 Patent provides no discussion or any evidence that the claimed range of texture coefficients of a (220) plane shows unexpected results relative to the prior art range or that it is more than the discovery of an optimum range by routine experimentation. On the other hand, the general significance of specific “crystalline phase characteristics,” including the texture coefficient of the (220) plane, was known. SOLUS-1009 at Abstract (“The (220)-oriented Cu foils possessed a superior combination of tensile strength and ductility”). Cheng as prior art also discloses the general significance of specific “crystalline phase characteristics,” including specifically the texture coefficients of (220) planes and provides a range of values overlapping the claimed range such that “the roughness of both sides of the electrolytic copper foil [are] low and the roughness difference between both sides [are] extremely small.” SOLUS-1007 at 10:27-34. Therefore, as a POSITA would have recognized, the general conditions of the claimed range of texture coefficient of a (220) plane were disclosed in prior art, and the significance of the texture coefficient of a (220) plane was already recognized in prior art. Since the ’014 patent’s range of values fail to show unexpected results relative to prior art, since they are not more than the discovery of the optimum or

workable range of values, and since the general significance of “crystalline phase characteristics” had already been disclosed, the Hanafusa-Dobashi-Cheng combination renders obvious the ’014 patent’s range of values for the texture coefficient of a (220) plane.

C. [GROUND 1C] — Claim 3 is Obvious over the Hanafusa-Dobashi-Kim Combination

1. Overview of Kim

109. As I demonstrate below, Kim describes copper foil allowing uniform application of negative-electrode material through optimization of factors including surface roughness and weight deviation. For example, Kim describes a “copper foil for a current collector of a lithium secondary battery, wherein factors such as surface roughness, **weight deviation**, tensile strength, elongation, and thickness are optimized. . . to decrease the generation of **wrinkles** at the surface of the copper foil.” SOLUS-1008 at 2:4-9. Kim teaches that prevention of wrinkles at the surface of the foil makes it “possible to form a uniform coating surface and prevent a short circuit when being coated with active material.” *Id.* at 2:30-35. Thus Kim describes optimizing factors including surface roughness (e.g., “surface roughness (Rz-JIS) of 2 μ m or less”) and weight deviation (e.g., “weight deviation of 3% or less”) for a copper foil which prevents wrinkles at the surface of the foil, thus making possible a uniform coating surface. SOLUS-1008 at cl. 1.

2. The Hanafusa-Dobashi-Kim combination

110. In addition to the surface roughness characteristics described in Hanafusa-Dobashi, the electrolytic copper foil in Hanafusa-Dobashi-Kim, as I demonstrate below, would have a weight deviation of 3% or less in lateral direction of the foil, as taught by Kim, thereby preventing wrinkles at the surface of the foil as intended by Kim and making it possible to form a uniform coating surface as intended by Hanafusa. SOLUS-1008 at cl. 1; SOLUS-1004, [0061] (“apply[ing] the “negative-electrode material uniformly on both sides of the copper foil”).

111. In my view, a POSITA would have been motivated to implement Hanafusa-Dobashi’s electrolytic copper foil to have the weight deviation of 3% or less in the lateral direction, as taught by Kim.

112. Specifically, a POSITA would have understood that Kim’s teaching of the weight deviation (synonymus with copper foil uniformity) would facilitate the purpose of Hanafusa-Dobashi. For example, Hanafusa recognizes the importance of surface roughness and adhesion of negative-electrode material on the surface of the foil. SOLUS-1004, [0029] (“If the surface roughness Rz of the copper foil is less than 1.0 μm , adhesion to a negative-electrode material tends to decrease.”). Similarly, Kim identifies the disadvantages of active material being not uniformly coated “due to the irregularity of the surface,” which would “cause short-circuit or **separate the active material from the copper foil** during a charging or discharging

process.” SOLUS-1008 at 1:57-61 (emphasis added). Therefore, Kim describes that an electrolytic copper foil with weight deviation of 3% or less and no wrinkles makes it “possible to form a uniform coating surface and prevent a short circuit when being coated with active material.” SOLUS-1008 at 2:30-35. Thus a POSITA would have understood that the electrolytic copper foil with this weight deviation in the Hanafusa-Dobashi-Kim would benefit from Kim’s weight deviation and accomplish what’s intended in Hanafusa; to ensure adhesion of the electrolytic copper foil to a negative-electrode material.

113. Based on my knowledge and experience in the field, a POSITA would also have readily recognized that Hanafusa-Dobashi’s foil would further benefit from Kim’s weight deviation features. For example, Kim describes that the weight deviation of 3% or less in lateral direction prevents “property deviations” at the surface of the copper foil, which may “increase the number of wrinkles and make properties of the current collector **irregular**.” SOLUS-1008 at 4:24-29.

114. Furthermore, a POSITA would have understood that weight deviation is linked to property deviations such as surface roughness and microscopic copper crystal orientation and texture coefficient, thereby making weight deviation a parameter that encompasses the physical and crystallographic properties that are critical to adhesion and the formation of non-uniformity in the copper foil that can lead to wrinkles. In the Hanafusa-Dobashi-Kim combination, Kim’s teaching of

weight deviation of 3% or less and no wrinkles would enable Hanafusa-Dobashi's copper foil to have "excellent peel strength" because "sufficient adhesive force is ensured when the copper foil is contacted with anode active material." SOLUS-1008 at 5:45-50.

115. A POSITA would also understand or otherwise find it obvious that in the Hanafusa-Dobashi-Kim combination, Kim's teaching of weight deviation of 3% or less and no wrinkles would enable Hanafusa-Dobashi's copper foil to make possible "a lithium secondary battery that may stably keep a battery capacity." SOLUS-1008 at 5:48-51.

116. Furthermore, as I demonstrate below, this implementation is merely the application of known techniques (e.g., foil with weight deviation of 3% or less) to a known structure (e.g., the Hanafusa-Dobashi composition and surface structure) to yield predictable results (e.g., an electrolytic copper foil with a uniform coating surface—e.g., no wrinkles—allowing for "excellent peel strength" due to "sufficient adhesive force" when the copper foil contacts anode active material for a lithium secondary battery). SOLUS-1008 at 5:45-50. As a POSITA would have understood, the copper foil of Kim is very similar to the structural, chemical, and metallurgical characteristics to that of Hanafusa-Dobashi. The copper foil of Kim, like the copper foil of Hanafusa-Dobashi as discussed in section VII.A.3., is made "by means of electroplating," for use as "material of the anode current collector" in a "lithium

secondary battery.” SOLUS-1008 at 1:30-45. As such, the copper foil of Kim, like that of Hanafusa-Dobashi, is “coated with a protective layer. . . so as to ensure corrosion resistance.” *Id.* at 1:48-50. Identical to the copper foil of Hanafusa-Dobashi, the copper foil of Kim is “coated with active material” and has factors such as “surface roughness” that are “optimized” to ensure “adhesion of active material to the surface of the copper foil.” *Id.* at 1:39, 3:1-5; 3:50-4:1. Thus the copper foil of Kim shares a known structure with that of Hanafusa-Dobashi.

117. As I demonstrate below, a POSITA would have had a reasonable expectation of success in making Hanafusa-Dobashi’s electrolytic copper foil with weight deviation of 3% or less in lateral direction as taught by Kim. Indeed, a POSITA would have recognized that, according to Hanafusa, the electrolytic copper foil surface characteristics—e.g., surface roughness—would affect “adhesion to a negative-electrode material” (SOLUS-1004 at [0012]) and that wrinkling, which is one such copper foil characteristic, is affected by **weight deviation** along with surface roughness and texture coefficient. SOLUS-1008 at 1:52-57. Based on this understanding, a POSITA would have recognized that the Hanafusa-Dobashi-Kim combination would require only routine implementation techniques, which were well within the POSITA’s skill. In fact, the composition of Kim’s electrolytic copper foil is generally similar, as would have been understood by a POSITA, to that of the Hanafusa-Dobashi electrolytic copper foil as both are intended for use as current

collector of a lithium secondary battery. SOLUS-1008 at 1:52-57, 5:45-50; SOLUS-1004 at [0001].

3. Analysis of Claim 3

[3] The electrolytic copper foil according to claim 1, wherein a weight deviation in lateral direction of the electrolytic copper foil is less than 3%.

118. As I demonstrate below, Hanafusa-Dobashi-Kim renders claim 3 obvious. In the combination, the “electrolytic copper foil” is implemented with foil surface characteristics prescribed in furtherance of improved “adhesion to a negative-electrode material” or “sufficient adhesive force” when the copper foil “is contacted with anode active material.” SOLUS-1004 at [0029]; SOLUS-1008 at 5:45-50. Such foil surface characteristics prescribed include, based on Kim, at least foil with “weight deviation of **3% or less.**” SOLUS-1008 at 2:24-25, 4:24-30, 6:44-45, Abstract, (emphasis added). Such range of weight deviation, as disclosed in Kim, overlaps considerably with the claimed range of “weight deviation in lateral direction of the electrolytic foil is **less than 3%,**” Thus renders the claimed range obvious. SOLUS-1001 at cl. 3 (emphasis added).

119. Additionally, as I demonstrate below, there is no indication in the '014 patent that the claimed range of weight deviation shows unexpected results relative to the prior art and the '014 patent fails to show that the claimed range is critical.

120. Here, the '014 Patent provides no discussion or any evidence that the claimed range of weight deviation shows unexpected results relative to the prior art

range or that it is more than the discovery of an optimum range by routine experimentation. On the other hand, Kim as prior art disclosed the general significance of specific factors, including weight deviation, in furtherance of a copper foil for a current collector of a lithium secondary battery with “sufficient adhesive force” when the foil is “contacted with anode active material.” SOLUS-1008 at 5:45-50. Accordingly, the general conditions of the claimed range of weight deviation was disclosed in prior art; the significance of weight deviation was recognized in prior art. Since the ’014 patent’s range of values fail to show unexpected results relative to prior art, since they are not more than the discovery of the optimum or workable range of values, and since the general significance of “weight deviation” has already been disclosed, it is my view that the Hanafusa-Dobashi-Kim combination renders as obvious the ’014 patent’ range of values for weight deviation.

121. I note that Kim’s measurements and calculations used to determine weight deviation of an electrolytic copper foil are substantially the same (if not identical) in my view as those in the ’014 patent. In particular, the ’014 patent describes:

“the weight deviation in lateral direction of the electrolytic copper foil is calculated by cutting the copper foil to an area of 5 cmX5 cm to make a sample, measuring the weight of the sample and converting the measured weight into a weight value of the copper foil per unit area, repeatedly performing the sample cutting process in the lateral direction of the copper foil,

measuring weight values of the copper foil of respective samples, and calculating a standard deviation.”

SOLUS-1001 at 6:25-35. This is identical to the measurements and calculations disclosed by Kim to determine weight deviation:

“the weight deviation is obtained by cutting a copper foil by an area of 5 cmX5 cm to make a test piece, measuring weight of the test piece and converting the weight into a weight of the copper foil per a unit area, cutting the test piece along a width direction of the copper foil, repeating the above processes to measure weights of copper foils of every test piece, and then calculating a standard deviation.”

SOLUS-1008 at 4: 28-36.

122. Because the measurements and calculations for weight deviation as disclosed by Kim are identical to that of the '014 patent, Kim, as implemented in the combination, provides the “weight deviation in lateral direction” limitation of the '014 patent.

D. [GROUND 1D] — Claims 5 and 6 are Obvious Over the Hanafusa-Dobashi-Lee Combination

1. Overview of Lee

123. At a high level, Lee describes “an electrolytic copper foil for a secondary battery” with “excellent flexural endurance” and “a method for producing the electrolytic copper foil.” SOLUS-1006, Abstract. Lee describes the need for such an electrolytic copper foil with “excellent flexural endurance” “such that the copper foil can withstand a stress due to the expansion and contraction of the active material layer when charging/discharging of the battery is repeated.” *Id.* at 2:17-25. Lee

discloses that the electrolytic copper foil is “produced from a plating solution, containing total organic carbon (TOC), cobalt and arsenic.” *Id.* at Abstract.

2. The Hanafusa-Dobashi-Lee combination

124. As I demonstrate below, the Hanafusa-Dobashi-Lee combination would have provided a method of manufacture of electrolytic copper foil that would include, based on Lee’s teachings, the use of a plating solution with a specified amount of total organic carbon, cobalt and arsenic. *See* SOLUS-1004, [0037]; SOLUS-1006, Abstract. Notably, the Hanafusa-Dobashi combination renders obvious a method of manufacturing an electrolytic copper foil, including (1) the electroplating of copper film (2) through use of a rotary negative electrode drum, (3) a positive electrode plate, (4) the application of a current between them (5) while disposed in an electrolytic solution contained in an electrolytic bath, and (6) the provision of a rust-proof chromium layer on the surface of the copper film to prevent surface oxidation. SOLUS-1004, [0013], [0016], [0018], [0019], [0021], Fig. 1, [0037]; SOLUS-1005, 8:49-64.

125. While the electrolytic solution as disclosed by Hanafusa-Dobashi (see (5) above) would have contained nitride-containing organic compound (*see* SOLUS-1004, [0037]), Hanafusa-Dobashi does not, in my view, expressly describe specifics of the solution being used. However, as part of the investigation to implement Hanafusa-Dobashi’s manufacturing method, a POSITA would have looked for other

references, such as Lee, to determine an electrolytic solution. Thus, a POSITA would have recognized, that the method of manufacture in the Hanafusa-Dobashi combination would be improved through adoption of Lee's teachings of using a plating solution with a specified amount of total organic carbon, cobalt and arsenic. SOLUS-1006, Abstract; *see infra* Section IV.D.3 (analysis of claims 5-6).

126. As I demonstrate below, several reasons would have prompted a POSITA to implement the manufacture of the electrolytic copper foil in the combination using the plating solution having the total organic carbon, cobalt and arsenic based on Lee.

127. Among various reasons, a POSITA would have been motivated to pursue this implementation to achieve additional benefits provided by Lee's manufacturing solutions. For example, a POSITA would have appreciated that Lee's disclosure of a plating solution with the specific amounts of total organic carbon, cobalt and arsenic would allow "copper foil physical properties to be uniform," thus improving "flexural endurance" of the copper foil. *Id.*; SOLUS-1006, 2:37-41, 4:61-67, 6:5-21. Lee further describes that such an improved flexural endurance would "improve battery lifespan cycle properties and prevent cracking." *Id.*, 4:61-67. Accordingly, a POSITA would have been motivated to produce the electrolytic copper foil for a secondary battery according to Lee's teachings to add these advantages. In fact, Hanafusa recognizes the significance of flexibility in electrolytic

copper foil to prevent breakage or cracks, as demonstrated by “sufficient proof stress, which is an indicator of resistance to breakage” and confirms that when “flexibility is lost. . . it may cause crack generation.” SOLUS-1004, [0026].

128. A POSITA would have had a reasonable expectation of success in the use of the total organic carbon, cobalt and arsenic towards manufacture of Hanafusa-Dobashi’s copper foil. Notably, the electrolytic copper foil in Hanafusa-Dobashi and Lee are similar as both are intended for use as current collector of a lithium secondary battery. *See* SOLUS-1004, [0001]; SOLUS-1006, 2:29-35. Further, a POSITA would have understood that the commonly used rotating drum method of manufacturing the electrolytic copper foil in Hanafusa-Dobahis and Lee are similar, since both use the electrolysis method including an electrolytic bath containing electrolyte, a drum (cathode), a metal anode, and the application of an electrical potential between them. *See* SOLUS-1004, [0016]; SOLUS-1006, 1:38-50.

129. Further, a POSITA would have been motivated to achieve this implementation because doing so is merely the application of known techniques (e.g., total organic carbon, cobalt and arsenic as an additive in the electroplating solution) to a known structure (e.g., Hanafusa’s electrolytic copper foil) to yield predictable results (e.g., an electrolytic copper foil produced through use of electroplating solution containing total organic carbon, cobalt and arsenic as an additive).

3. Analysis

(i) Claim 5

[5pre] A method of manufacturing an electrolytic copper foil, the method comprising:

130. To the extent the preamble is deemed to be limiting, Hanafusa discloses

[5pre] or Hanafusa-Dobashi-Lee renders it obvious.

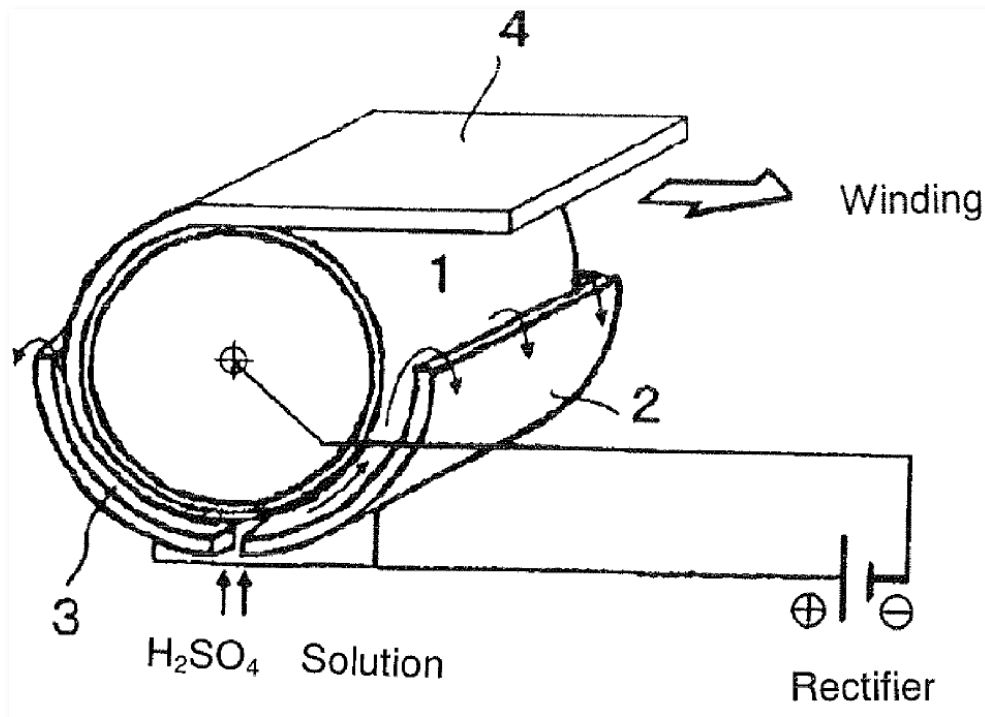


Fig. 1 of Hanafusa

131. Referring to Fig. 1, Hanafusa describes, “an electrolytic copper foil manufacturing apparatus.” SOLUS-1004, [0015], [0017]. For example, Hanafusa explains:

“As the cathode drum 1 rotates, the thickness of the copper electrodeposited from the electrolyte increases; and when the thickness of the electrodeposited copper reaches a certain value . . . this raw copper foil 4 is peeled off and continuously wound

up. . . **Regarding the copper foil manufactured** by the above-described electrolytic copper foil manufacturing apparatus, a surface of the copper foil in contact with the cathode drum becomes a mirror surface, while the other surface becomes a rough surface with asperity.”

SOLUS-1004 at [0021]-[0022] (emphasis added).

132. Thus, Hanafusa discloses an apparatus for manufacturing electrolytic copper foil and describes the process by which such apparatus is used to manufacture electrolytic copper foil.

133. In addition, Lee discloses a method of manufacturing an electrolytic copper foil. SOLUS-1006 at FIG. 2 (below).

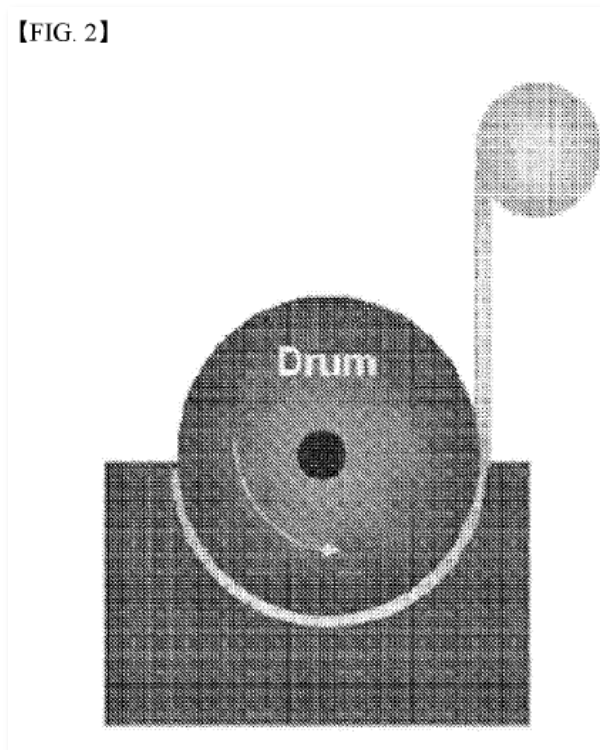


FIG. 2 of Lee

134. In particular, Lee discloses in Fig. 2 “a process of producing an

electrolytic copper foil using a drum according to one embodiment of the present disclosure.” SOLUS-1006 at 3:60-62. Lee also explains that it provides “a method for producing an electrolytic copper foil for a secondary battery, the method comprising. . .” *Id.* at 3:8-10.

135. Accordingly, Hanafusa-Dobashi-Lee discloses a method of manufacturing electrolytic copper foil, as taught by Lee.

[5a] electroplating a copper film on a rotary negative electrode drum by applying current between a positive electrode plate and the rotary negative electrode drum disposed in an electrolytic solution contained in an electrolytic bath so as to be spaced apart from each other;

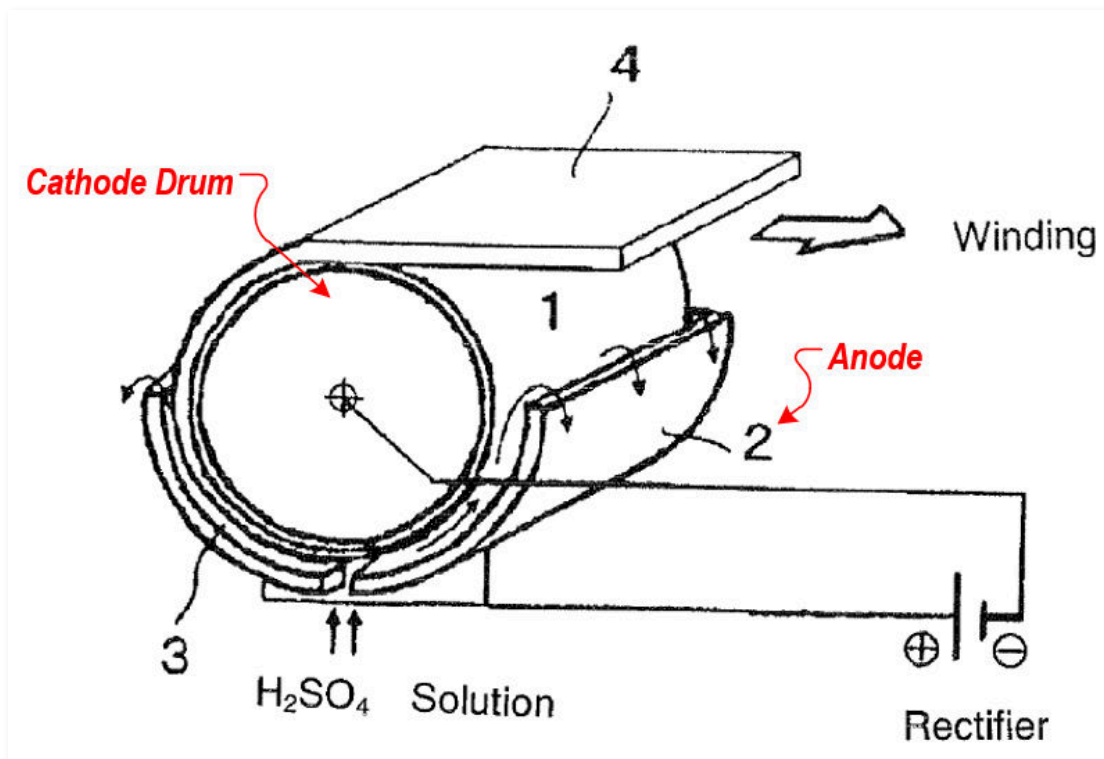
136. As I demonstrate below, Hanafusa discloses the manufacturing method of an electrolytic copper foil which comprises (a) electroplating a copper film (b) on a rotary negative electrode drum (c) by applying current between a positive electrode plate and the rotary negative electrode drum (d) disposed in an electrolytic solution contained in an electrolytic bath so as to be spaced apart from each other.

Electroplating a Copper Film

137. Hanafusa’s manufacturing method includes electroplating a copper film. In Hanafusa, for example, “[a]s the cathode drum **1** rotates, the thickness of **the copper electrodeposited** from the electrolyte increases.” SOLUS-1004, [0021]; *see also* [0016] (“electrodepositing copper onto the cathode drum by flowing copper electrolyte between the cathode drum and the anode and applying an electrical potential between them”).

Rotary Negative Electrode Drum

138. I note that Hanafusa's manufacturing method includes a rotary negative electrode drum. In Hanafusa, for example, "an electrolytic copper foil is continuously manufactured by: using **a rotating metal cathode drum** whose surface is polished, and an insoluble metal anode (positive electrode) placed to surround. . . the lower half part of the cathode drum." SOLUS-1004, [0016] (emphasis added), Fig. 1 (below).



Annotated Fig. 1 of Hanafusa (SOLUS-1004)

139. Hanafusa Fig. 1 shows a "**cathode drum 1**" which is "**designed to rotate**" and describes a "specified voltage. . . between the cathode drum **1** and the anode **2** via rectifier." SOLUS-1004 at [0018]-[0020]. Further, Fig. 1 shows the

rectifier applying a **negative** voltage to the cathode drum **1**, while applying a positive voltage to anode **2**. *See* SOLUS-1004 at Fig. 1.

Applying Current Between Positive Plate and Negative Drum

140. In my view, a POSITA would have understood and found obvious that Hanafusa's manufacturing method includes applying a current between a positive electrode plate and the rotary negative electrode drum. In Hanafusa, for example, "[a]n electrolytic copper foil was manufactured using an apparatus, as shown in FIG. 1. . . the **current** density was 50 A/dm²." SOLUS-1004, [0037] (emphasis added). Further, Hanafusa Fig. 1 shows that the rectifier applies a **negative** voltage to the cathode drum 1, while applying a positive voltage to anode 2. *See* SOLUS-1004, Fig. 1. Hanafusa further describes the anode as "[t]wo **anode plates** are placed in the apparatus shown in FIG. 1." SOLUS-1004, [0019] (emphasis added). Therefore, it would have been obvious to a POSITA that the described **current** was applied between the **positive anode plate** and the **negative cathode drum** of the apparatus, as shown in Hanafusa Fig. 1.

Plate and Drum in an Electrolytic Solution

141. Based on my knowledge and experience in the field, a POSITA would have recognized and found obvious that Hanafusa's manufacturing method includes the positive anode plate and the negative cathode drum disposed in an electrolytic solution contained in an electrolytic bath so as to be spaced apart from each other,

as disclosed in Hansfusa Fig. 1. For example, Hanafusa describes that “FIG. 1 shows a schematic view of an electrolytic copper foil manufacturing apparatus. This electrolytic copper foil apparatus is configured so that a **cathode drum** is set in an **electrolytic bath** which contains an **electrolyte**. . . There is a certain **space 3** between the cathode drum **1** and the anode **2**. . . the **electrolyte** flows between them.” SOLUS-1004, [0018]-[0019] (emphasis added).

[5b] winding the electroplated copper film;

142. A POSITA would have understood and found obvious that Hanafusa’s manufacturing method includes winding the electroplated copper film. In Hanafusa, “when the thickness of the **electrodeposited copper** reaches a certain value. . . this raw **copper foil 4** is peeled off and **continuously wound up**.” SOLUS-1004, [0021] (emphasis added), Fig. 1.

[5c] and immersing the copper film in an anti-corrosion solution for anti-corrosion treatment,

143. As noted above, Hanafusa describes that “a rust-proof chromium layer is provided on a surface of the electrolytic copper foil and a deposition amount of chromium in the rust-proof layer is 2.6 to 4.0 mg/m²” to “prevent surface oxidation of the electrolytic copperfoil.” SOLUS-1004, [0013], [0031]-[0033]. Based on my knowledge and experience in the field, immersing copper film in an anti-corrosion solution for anti-corrosion treatment was well-known to a POSITA. *See* SOLUS-1013, [0062] (“For the corrosion-proofing, the foil was dipped into a bath containing

3 g/L of CrO_3 and then dried to form a chromate layer”). Through these teachings, a POSITA would have understood and found obvious that Hanafusa’s manufacturing method of deposition of a rust-proof chromium layer on the surface of the electrolytic copper foil would include immersing the copper film in an anti-corrosion solution for anti-corrosion treatment for the reasons described in Hanafusa.

[5d] wherein, when the electroplating is performed, a concentration of total carbon is maintained at 0.12 g/L or less and

144. As I demonstrate below, the manufacturing method of Hanafusa-Dobashi-Lee electrolytic copper foil includes a concentration of total carbon of 0.12 g/L or less based on Lee’s teachings. SOLUS-1006, Abstract (“ . . . the present invention is an electrolytic copper foil for a secondary battery, which is produced from a plating solution, containing **total organic carbon** (TOC). . .” (emphasis added)), SOLUS-1006, Table 3 (showing total organic carbon values). It would have been obvious to a POSITA that Lee’s “total organic carbon” (“TOC”) is the “total carbon” (“TC”) as claimed by the ’014 patent. Lee teaches that **total organic carbon** “and metallic additives such as cobalt. . . are present in a certain amount in a copper electrolytic solution **to maintain the physical properties of the copper foil to be uniform** and thus to have a high flexural endurance.” SOLUS-1006, 3:44-49 (emphasis added). Similarly, the ’014 patent claims that where “the content of **[total carbon] TC exceeds 0.12 g/L** and the concentration of Co^{2+} exceeds 0.33 g/L. . . a copper foil having great **local quality deviation is manufactured**, and it is not

appropriate to use such a copper foil as a negative electrode current collector.” SOLUS-1001, 8:15-22 (emphasis added). Thus, a POSITA would have recognized as obvious that Lee’s “total organic carbon” (“TOC”) was equivalent, or corresponded, to “total carbon” (“TC”) as claimed by the ’014 patent. Both are disclosed as being used as an additive along with cobalt/ Co^{2+} to ensure uniformity of physical properties of copper foil and to avoid local quality deviation.

145. Lee discloses various ranges of total organic carbon (or total carbon) that fall within the claimed range (i.e., 0.12 g/L or less) of total carbon. SOLUS-1006, Table 3 (showing total organic carbon values); *see also* 2:60-63 (“In one implementation. . . a concentration of the total organic carbon contained in the plating solution is 100 ppm or greater.”).

TABLE 3

Examples	Bending times In MIT test	Battery lifespan of 300 cycles	TOC concentration	TOC/(Co + As) after dissolving copper foil
Present	120	88.3	340	1.45
Example 1				
Present	200	88.4	220	1.43
Example 2				
Present	111	88.5	101	1.35
Example 3				
Present	168	87.8	1050	1.47
Example 4				
Present	130	88.1	110	1.30
Example 5				
Present	150	88.2	640	1.40
Example 6				
Present	129	88.6	460	1.39
Example 7				
Present	250	87.4	320	1.54
Example 8				
Present	110	87.1	110	1.45
Example 9				
Comparative Example 1	88	82.9 (fracture or peeled)	83	1.11
Comparative Example 2	87	85.4 (fracture or peeled)	98	1.21
Comparative Example 3	86	81.8 (fracture or peeled)	72	1.15
Comparative Example 4	90	82.6 (fracture or peeled)	54	1.27

Annotated Table 3 of Lee (SOLUS-1006)

146. As shown above, Lee Table 3 discloses a range of “concentration of [total organic carbon] TOC contained in the plating solution” including a range of total organic carbon of 54 to 110 ppm, which a POSITA would have known is equivalent to 0.05 to 0.11 g/L. A range of 0.05 to 0.11 g/L is within the claimed range of 0.12 g/L or less. Thus, the Hanafusa-Dobashi-Lee combination makes

obvious the claimed range.

147. Based on my review, there is no indication in the '014 patent, that the claimed range of total carbon shows unexpected results or that the claimed range is critical. In particular, the '014 patent provides no discussion or any evidence that the claimed range of total carbon shows unexpected results relative to the prior art range or that it is more than the discovery of an optimum range by routine experimentation. On the other hand, the Hanafusa-Dobashi-Lee combination describes the significance of total organic carbon, including its effect on “crystal structure favorable to flexural endurance. . . of the electrolytic copper foil.” SOLUS-1006 at 6:15-21. Thus, the significance of total organic carbon, or total carbon, was already recognized in the prior art. Since the '014 patent's range of total carbon fails to show unexpected results relative to prior art, and since the general significance of total organic carbon effect on “crystal structure favorable to flexural endurance” has already been disclosed, it is my view that the Hanafusa-Dobashi-Lee combination renders as obvious the '014 patent's range of values for total carbon.

[5e] a concentration of Co^{2+} is maintained at 0.33 g/L or less.

148. Similarly, it is my view that the manufacture method of Hanafusa-Dobashi-Lee electrolytic copper foil includes a concentration of “ Co^{2+} ” of 0.33 g/L or less based on disclosures of Lee. SOLUS-1006 at Abstract (“ . . . the present invention is an electrolytic copper foil for a secondary battery, which is produced

from a plating solution, containing total organic carbon (TOC), **cobalt** and arsenic. . .”). It would have been obvious to a POSITA that “**cobalt**” would have included/ meant the cation Co^{2+} (“cobalt (II)”), as an additive to a plating solution for manufacture of electrolytic copper foil. Lee teaches that **total organic carbon “and metallic additives such as cobalt. . . are present in a certain amount in a copper electrolytic solution to maintain the physical properties of the copper foil to be uniform** and thus to have a high flexural endurance.” SOLUS-1006 at 3:44-49. Almost identically, the ’014 patent claims that where “the content of **[total carbon] TC exceeds 0.12 g/L** and the **concentration of Co^{2+} exceeds 0.33 g/L. . . a copper foil having great local quality deviation is manufactured**, and it is not appropriate to use such a copper foil as a negative electrode current collector.” SOLUS-1001 at 8:15-22. Thus, a POSITA would have recognized as obvious that Lee’s “cobalt” was equivalent to “ Co^{2+} ” as claimed by the ’014 patent. Both are disclosed as being used as an additive along with total organic carbon/ total carbon to ensure uniformity of physical properties of copper foil; to avoid local quality deviation.

149. Further Lee discloses a range of cobalt (or Co^{2+}) that falls within range of the claimed range of Co^{2+} . SOLUS-1006 at 5:47-53 (“In the plating solution. . . [t]he **cobalt may be contained at 1 mg/L to 50 mg/L**”), 7:65-67 (“A plating solution containing copper ions. . . sulfuric acid. . . chlorine. . . TOC. . . **cobalt 0.025 g/L**”). Therefore Lee discloses a range of cobalt in plating solution from 1 to 50

mg/L, which overlaps the claimed range of 0.33 g/L or less, and Thus the Hanafusa-Dobashi-Lee combination makes obvious the claimed range.

150. Additionally, I observe no indication in the '014 patent that the claimed range of Co^{2+} shows unexpected results relative to the prior art range and or that the claimed range is critical.

151. Here, the '014 patent provides no discussion or any evidence that the claimed range of Co^{2+} shows unexpected results relative to the prior art range or that it is more than the discovery of an optimum range by routine experimentation. On the other hand, the Hanafusa-Dobashi-Lee combination describes the significance of cobalt, including its use “to maintain the physical properties of the copper foil to be uniform and thus to have a high flexural endurance.” SOLUS-1006 at 2:32-36. Thus, the significance of cobalt, or Co^{2+} as a “metallic additive. . .present in a certain amount in a copper electrolytic solution” was already recognized in the prior art. SOLUS-1006 at 3:44-49. Since the '014 patent's range of Co^{2+} fails to show unexpected results relative to prior art, and since the general significance of cobalt's effect on “the physical properties of the copper foil to be uniform” has already been disclosed, the Hanafusa-Dobashi-Lee combination renders obvious the '014 patent's range of values for Co^{2+} . SOLUS-1006 at 2:32-36.

(ii) Claim 6

[6] The method according to claim 5, wherein a concentration of a nitrogen compound in the electrolytic solution is 3 to 12 ppm.

152. As I demonstrate below, the manufacture method for the Hanafusa-Dobashi-Lee electrolytic copper foil includes a concentration of a nitrogen compound in the electrolytic solution from 3 to 12 ppm based on Hanafusa. For example, Hanafusa discloses “[a]n electrolyte contained 85 g/L of copper, 75 g/L of sulfuric acid, 60 mg/L of chloride ions, 3-10 ppm of bis-(3-sulfopropyl)-disulfide sodium salt, and **2-20 ppm of nitride-containing organic compound.**” SOLUS-1004 at [0037]. A POSITA would have known that “nitride-containing organic compound,” disclosed by Hanafusa, is a nitrogen compound; a nitride is a chemical compound of nitrogen. This is especially true since the ’014 patent explicitly references nitride as an additive in its electrolytic solution. *See* ’014 patent, 8:26-30 (“the content of a **nitride in the electrolytic solution** may be adjusted to control the yield strength and adhesion force of the copper foil. In the present disclosure, **at least one nitride selected from the group consisting of diethylenetriamine (DETA).** .”).

153. Moreover, Hanafusa teaches that a range of nitride-containing organic compound in plating solution is **2-20 ppm**, which encompasses the claimed range of **3 to 12 ppm**. Thus, the Hanafusa-Dobashi-Lee combination makes obvious the claimed range.

154. Additionally, there is no indication in the ’014 patent that the claimed range of nitrogen compound shows unexpected results relative to the prior art or that

the claimed range is critical.

155. Based on my review, the '014 patent provides no discussion or any evidence that the claimed range of nitrogen compound shows unexpected results relative to the prior art or that it is more than the discovery of an optimum range by routine experimentation. Since the '014 patent's range of nitride-containing organic compound fails to show unexpected results relative to prior art, and since the use of nitride-containing organic compound in an electrolyte has already been disclosed, the Hanafusa-Dobashi-Lee combination renders obvious the '014 patent's range of values for nitrogen compound.

E. [GROUDN 1E] — Claim 7 is Obvious over the Hanafusa-Dobashi-Kajihara Combination

1. Overview of Kajihara

156. Kajihara describes, the treatment of copper foil to achieve a “rough surface good in bondability.” SOLUS-1012 at 2:52-54. For example, Kajihara describes “treating copper to make a rough surface” where the copper surface is “immersed into an aqueous solution containing **diethylenetriamine pentaacetic acid and copper ion** and **electrolysis is conducted** by using it as a cathode.” SOLUS-1012 at 2:21-29. Kajihara teaches specific ranges of **diethylenetriamine pentaacetate**, PH, temperature, and current density to obtain “bondability of rough surface.” SOLUS-1012 at 2:29-50. Thus, Kajihara describes optimizing surface roughness (e.g., “rough surface good in bondability”) for a copper foil, thus

improving “satisfactory peelstrength.” *Id.* at 2:54, 43-44.

2. The Hanafusa-Dobashi-Kajihara combination

157. As I demonstrate below, in addition to meeting the surface roughness characteristics described in Hanafusa-Dobashi, the electrolytic copper foil in Hanafusa-Dobashi-Kajihara would have been subject to a surface treatment process using “an aqueous solution containing diethylenetriamine pentacetic acid,” as taught by Kajihara, making it possible to optimize surface roughness and thus improving “satisfactory peelstrength,” in furtherance of improving the “adhesion of the copper foil” as intended by Hanafusa. SOLUS-1012 at 2:26-27, 43-44; SOLUS-1004, [0061] (“if the surface roughness (Rz) is less than 1.0 μm , the adhesion of the copper foil. . . is weak and the copper foil will come off as a result of the charge-discharge test.”).

158. For several reasons, a POSITA would have been motivated to implement Hanfusa-Dobashi’s electrolytic copper foil subject to the treatment as taught by Kajihara, including electrolysis in an aqueous solution containing diethylenetriamine pentacetic acid.

159. A POSITA would have understood that Kajihara’s teaching of the copper foil surface roughness treatment would facilitate the purpose of Hanafusa-Dobashi. For example, Hanafusa recognizes the importance of **surface roughness and adhesion** of negative-electrode material on the surface of the foil. SOLUS-

1004, [0029] (“If the **surface roughness** Rz of the copper foil is less than 1.0 μm , **adhesion** to a negative-electrode material tends to decrease.”). Further, a POSITA would have understood based on Hanafusa that “the surface roughness of the electrolytic copper foil can be adjusted by an additive to the electrolyte,” and also that “known methods for adjusting the surface roughness can be arbitrarily used.” SOLUS-1004 at [0028].

160. Here, a POSITA would have understood that Kajihara similarly identifies the disadvantages of having a “**rough surface**” that is “extremely minute” and making it “difficult to obtain **satisfactory peelstrength**.” SOLUS-1012 at 2:41-45. A POSITA would have thus recognized that Kajihara’s copper foil surface roughness treatment (e.g., electrolysis in an aqueous solution containing the **additive** diethylenetriamine pentacetic acid) was, as also identified by Hanafusa, a way by which “the surface roughness of the electrolytic copper foil [could] be adjusted by an **additive** to the electrolyte,” making possible a “rough surface good in bondability.” SOLUS-1004, [0028]; SOLUS-1012 at 2:53-54. Therefore, a POSITA would have understood, that the electrolytic copper foil that had undergone such surface roughness treatment would benefit from Kajihara’s “rough surface good in bondability” and accomplish what’s intended in Hanafusa; to ensure adhesion of the electrolytic copper foil to a negative-electrode material. SOLUS-1012 at 2:53-54.

161. Furthermore, a POSITA would have readily recognized, that Hanafusa-

Dobashi's foil would further benefit from Kajihara's surface roughness treatment (e.g., electrolysis in an aqueous solution containing diethylenetriamine pentacetic acid). For example, Kajihara describes that such surface treatment would provide electrolytic copper foil with "sufficient peeling strength" as measured in "(Kg/cm)*2." SOLUS-1012 at TABLE 2. A POSITA would have recognized additional advantages of Kajihara's surface treatment which include having "few process steps, a short treatment time, and not requiring any high temperature treatment." SOLUS-1012 at 2:15-20.

162. In my view, a POSITA would have understood that implementation is merely the application of known techniques where additives in the plating solution can affect the surface roughness characteristics and microcrystal properties (e.g., foil subject to surface treatment through electrolysis with conventional additives) to a known structure (e.g., the Hanafusa-Dobashi composition) to yield predictable results (e.g., an electrolytic copper foil with optimized surface roughness allowing for "sufficient peeling strength" due to "rough surface good in bondability"). SOLUS-1012 at 2:13, 53-55. A POSITA would have understood the copper foil of Kajihara to be very similar in structure and characteristics to that of Hanafusa-Dobashi. For instance, the copper foil of Kajihara, like the copper foil of Hanafusa-Dobashi as discussed in section VII.A.3., is an "electrolytic copper foil." SOLUS-1012 at 3:38-39; 4:7-10; 5:27-31. The surface of the copper foil of Kajihara, also

similar to that of Hanafusa-Dobashi, may be “subject to general chromate treatment.” *Id.* at 2: 64-65. Identical to the copper foil of Hanafusa-Dobashi, the copper foil of Kajihara optimizes factors such as “rough surface” to ensure “sufficient peeling strength.” *Id.* at 2:21-22; 2:12-14. Thus, it is my view that the copper foil of Kajihara shares a known structure with that of Hanafusa-Dobashi.

163. A POSITA would have had a reasonable expectation of success, in making Hanafusa-Dobashi’s electrolytic copper foil subject to the surface roughness treatment as taught by Kajihara. Indeed, a POSITA would have recognized that, according to Hanafusa, the electrolytic copper foil surface characteristics—e.g., surface roughness—would affect “adhesion to a negative-electrode material.” SOLUS-1004 at [0012]. Based on Hanafusa a POSITA would, have also understood that “the surface roughness of the electrolytic copper foil can be adjusted by an additive to the electrolyte” and that “known methods for adjusting the surface roughness can be arbitrarily used.” SOLUS-1004 at [0028]. As such, a POSITA would have recognized the surface treatment of Kajihara— a “known method” where “an additive to the electrolyte” is used to adjust the degree of surface roughness of the electrolytic copper foil— would be in furtherance of the Hanafusa-Dobashi electrolytic copper foil. Therefore it is my view that the Hanafusa-Dobashi-Kajihara combination would require only routine implementation techniques, which were well within the POSITA’s skill. In fact, the composition of Kim’s electrolytic

copper foil is generally similar to that of the Hanafusa-Dobashi electrolytic copper foil as both are electrolytic copper foils subject to electrolysis with additives and chromate treatment. *See* SOLUS-1012 at 3:38-39; 4:7-10; 5:27-31; 2:64-65; SOLUS-1004, [0001].

3. Analysis

(i) Claim 7

[7] The method according to claim 6, wherein the nitrogen compound comprises DETA, and:

[7a] a concentration of the DETA is 3.2 to 12 mg/L.

164. As I demonstrate below, the manufacture method for the Hanafusa-Dobashi-Kajihara electrolytic copper foil includes a nitrogen compound comprising DETA based on Kajihara. For example, Kajihara discloses “an aqueous solution containing **diethylenetriamine pentaacetic acid** and copper ion.” SOLUS-1012 at 2:25-28. In my view a POSITA would have known that “**diethylenetriamine pentaacetic acid**,” disclosed by Kajihara, is equivalent to diethylenetriamine; both are a chemical compound of nitrogen. Moreover, both are used as additives in electrolytic solution in furtherance of **increasing adhesiveness of the copper foil**. SOLUS-1001 at 8:26-32 (“Specifically, the content of a nitride in the electrolytic solution may be adjusted to control the yield strength and **adhesion force of the copper foil**. In the present disclosure, at least one nitride selected from the group consisting of diethylenetriamine (DETA) . . . may be used as a preferred nitride.”);

SOLUS-1012 at 2:20-50 (“The primary object of the invention is to provide a method of surface treatment having. . . sufficient peeling strength. . . [the copper surface] is immersed into an aqueous solution containing diethylenetriamine pentaacetic acid. . .”) Thus, a POSITA would have known, that “diethylenetriamine (DETA)” includes “diethylenetriamine pentaacetic acid,” disclosed by Kajihara. Thus, it is my view that Hanafusa-Dobashi-Kajihara discloses DETA as a nitrogen compound.

165. As I discussed previously above in VII.D.3.(ii) (analysis of claim 6), Hanafusa discloses a range of nitride-containing organic compound in plating solution from 2-20 ppm, which encompasses the claimed range of 3.2 to 12 mg/L. As a POSITA would have understood, this disclosure of 2-20 ppm range of nitride-containing organic compound combined with Kajihara’s disclosure of diethylenetriamine pentaacetic acid as a nitride compound thus makes the claimed range obvious.

166. Additionally, there is no indication in the ’014 patent that the claimed range of diethylenetriamine shows unexpected results relative to the prior art or that the claimed range is critical.

167. The argument that Kajihara’s disclosure of a range of diethylenetriamine pentaacetate at 10-100 g/l is contrary to the claimed range of 3.2 to 12 mg/L would fail, since the ’014 patent provides no discussion or any evidence

that the claimed range of diethylenetriamine shows unexpected results relative to the prior art, nor that it required anything more than optimization through routine experimentation. Since the '014 patent's range of nitride-containing organic compound, including that of diethylenetriamine, fails to show unexpected results relative to prior art, and since the use of nitride-containing organic compound including diethylenetriamine in an electrolyte has already been disclosed through Kajihara, the Hanafusa-Dobashi-Kajihara combination renders obvious the '014 patent's range of values for diethylenetriamine.

VIII. LEGAL PRINCIPLES

A. Anticipation

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

B. Obviousness

169. I have been informed that a patent claim is invalid as “obvious” under 35 U.S.C. § 103 in light of one or more prior art references if it would have been obvious to a POSITA, taking into account (1) the scope and content of the prior art, (2) the differences between the prior art and the claims, (3) the level of ordinary skill in the art, and (4) any so called “secondary considerations” of non-obviousness,

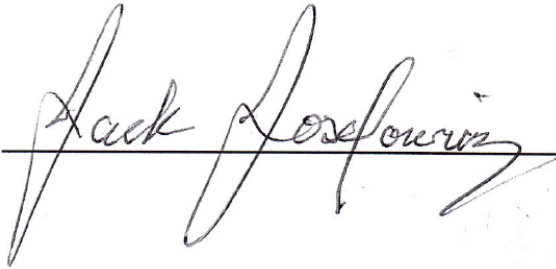
which include: (i) “long felt need” for the claimed invention, (ii) commercial success attributable to the claimed invention, (iii) unexpected results of the claimed invention, and (iv) “copying” of the claimed invention by others.

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

IX. CONCLUSION

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

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

Dated: Sept. 20, 2024 By: 

APPENDIX A

Dr. Jack Josefowicz/jack.josefowicz@gmail.com

Cell: (310) 874-2261

PROFESSIONAL COMPETENCE OVERVIEW:

Dr. Jack Josefowicz's background includes basic research and downstream "real world" issues in electronic materials, electronic micro-devices, electronic systems design, electrochemical systems, and failure analysis. Dr. Josefowicz also has expertise in surface science, including deposition techniques for thin films in applications that include, printed circuit board fabrication (PCB) technology, root cause failure analysis in PCBs as well as semiconductor microchip and microprocessor devices.

Dr. Josefowicz is an independent consultant, working with both the commercial and aerospace electronic industries. Dr. Josefowicz has worked with law firms to support litigation, defend patent infringement cases and served as an expert witness in legal mediation cases. Dr. Josefowicz is an expert in electronic system reliability prediction analysis, electronic systems failure and root cause analysis, electronic fabrication "best practice." Holding the position of Director of Technology Research and Development at Tyco Printed Circuit Division, Dr. Josefowicz headed the Engineering teams at 13 printed circuit board manufacturing facilities (with sales of \$1.3 Billion) located throughout the world. This position included best practice manufacturing development involving statistical process control, design for manufacturing and reliability testing. Dr. Josefowicz was the lead and responsible for "root cause" analysis PCB failures related to production related process deviations that resulted in electronic system failures. This included surface finishes problems, as well as plating and through hole plating failures. Additionally, such failures often caused overheating of devices resulting in burns and fires. In one expert witness case, Dr. Josefowicz's expert witness analysis of electronic system failures related surface finish problems involving electroless Ni immersion gold that had an exposure of \$100 million resulted in a positive settlement and no liability for his client, and the chemical supplier who had a problem was identified. During his tenure at Tycoelectronics, Dr. Josefowicz headed a task force for contingent liabilities and was the lead in 45 cases that had an exposure of over \$500M. In most of those liability cases, Dr. Josefowicz participated in depositions and mediations in front of a judges. In all those cases, Dr. Josefowicz headed all the analysis, wrote the analysis reports, and defended the results of analysis.

Dr. Josefowicz was also head of research and design applied to large scale Li-Ion battery development for space satellites at Hughes Research Laboratories, Malibu, CA, including manufacturing, testing and product design and large area Li-Ion cell fabrication technology.

Dr. Josefowicz also has hands on expertise includes materials science. This includes a wide range of atomic level analytical methods that includes, Scanning Electron Microscopy, 3-D Digital High Resolution Micrography, Electron Dispersive X-Ray analysis (XRD), Auger Depth Profiling Electron Spectroscopy, Fourier Transform Infrared Analysis, Thermogravimetric Analysis, Cross-section analysis and other microscopic methods that determine the chemical and structural composition of materials related to electronic devices, including LED device battery analysis.

Dr. Josefowicz has hands on electronic and engineering applications that include the Light Emitting Diode (LED) device design, LED light fixture design and optimization, LED Light Engine printed circuit boards (PCB, including design and fabrication of advanced high layer count printed circuit boards up to 64 layers,), LED assembly on metal core PCBs including pick and place SMD LED devices and reflow assembly, SMD surface finish materials expertise, advanced electronics for LED power supply drivers and controllers, electronic system reliability, semiconductor device reliability. As an independent consultant, Dr. Josefowicz has served as expert witness in 45 cases involving all aspects of LED luminaire design, including claim definition, IPR, patent claim invalidity and has been deposed in these cases.

Dr. Josefowicz's career began with basic research at Harvard University, followed by applied industrial R&D (at Hughes Research Laboratories (HRL)) as well as university research as Professor of Material Science and Engineering (University of Pennsylvania). Projects at HRL included design and fabrication of unique thin film depositions systems, including sputtering, e-beam evaporation, chemical vapor deposition, doctor blade coating techniques for cathodes,

anodes and electrolyte gels used in Li-Ion large area batteries, induction heat deposition and other methods where the thin films were applied to optical and electronic systems. Having established a reputation in several science fields through publications and patents. Dr. Josefowicz led the design of Light Emitting Diode (LED) lighting fixtures at LED Roadway Lighting Ltd. (LRL). As Executive VP of Technology, Dr. Josefowicz helped launch LRL and led the design of new globally acclaimed high efficiency and high reliability LED streetlights, including electronics power supply driver, LED control systems including dimming and on/off controls, optics design, and fixture housing design for optimized thermal management. Dr. Josefowicz also directed the qualification of suppliers for all the components that included, electronic devices and components, PCB suppliers, die cast and mould design for lean and design for manufacturing, as well as parts and system integration. The intimate bridging between R&D and manufacturing design were pursued and were critical to high yield and reliability of the manufactured parts.

Having given invited talks and presentations at international conferences, Dr. Josefowicz has strong communication skills in making science and engineering accessible to non-experts and experts alike.

Technology Expertise:

1. Li ion battery design, materials development and engineering optimization (liquid and polymer gel ionic separator selection and design); thin film coating technology (doctor blade, spray and spreading methodologies), including testing; charging and discharging characteristic analysis and optimization.
2. LED light design:
 - a. LED device design including semiconductor p-n junction fabrication and phosphor wavelength conversion materials science
 - b. Optics for LED devices
 - c. Optics design for street lighting applications
 - d. Power supply driver electronics including dimming and on-off controls
 - e. Luminaire fixture design and thermal management design
 - f. Driver electronics reliability prediction analysis using Telcordia SR332
3. Thin Film Surface Finish Performance and Evaluations – Failure Root Cause Analysis
4. Thin film coating technology, including vacuum deposition design of equipment for plasma sputtering, electron beam deposition, RF plasma, and chemical vapor deposition.
5. Printed Circuit Design, Manufacturing Process Design for “Best Practice”
6. Molecular and Atomic analysis using Atomic Force Microscopy; Scanning Tunneling Microscopy for material science investigations of metals and insulators (ceramics, plastics, oxides, organometallics).
7. Expertise (hands on) in thin film coating of metals, semiconductors and insulators by methods including:
 - a. Thermal evaporation
 - b. Chemical Vapor Deposition
 - c. Radio frequency discharge deposition
 - d. Electron beam evaporation
 - e. Sputtering deposition
8. Electronic Reliability Prediction Modeling and Design for Long Life

WORK EXPERIENCE:

- A. Independent Consultant**
- B. LED Roadway Lighting Limited – Halifax, Nova Scotia, Canada/Executive VP, Technology Solutions and Head of R&D 2008 – 2012**
- C. Tycoelectronics/Printed Circuit Group – Los Angeles, CA
Director of Technology and R&D 1996 – 2008**
 - a. Direct manufacturing and operations in new emerging technology, overseeing the Tycoelectronics Printed Circuit Group, Aerospace, Military-High Reliability-10 manufacturing facilities >\$1Billion
- D. Hughes Research Laboratory, Malibu, CA-1985-1996**
 - a. **Principle Scientist and Project Leader 1984 – 1996**
 - b. **Li-Ion Design and Development Program to design and fabricate Li-Ion batteries for Space Satellites using advanced solid state thin film lithium polymer electrolyte battery designs**
 - c. Establish collaborative program (DARPA) between Hughes Research Labs and University of Pennsylvania (Penn) for the research and development of advanced solid-state thin film lithium polymer electrolyte batteries for Space Satellites
 - d. Constructed the first Atomic Force Microscopy laboratory at Penn for atomic analysis of materials applied to materials research and electrochemical analysis
 - e. Designed and fabricated Plasma RF Sputtered Superconducting Lattice Matched-on Sapphire Thin Films for Radio Frequency Devices band pass filters for space satellite applications
 - f. Program Lead: high temperature superconductors: DARPA Superconductor thin films program
 - g. Fabricated the world's first gallium arsenide high speed integrated circuits using self-aligned field effect transistors with pure tungsten gates; fabrication of large-scale high-speed integrated circuits using simple and reliable processes
- E. University of Pennsylvania**
 - a. **Professor**
- F. Harvard University: Cambridge, MA
Research Associate; 1975-1980**
- G. EDUCATION:**
 - a. **PhD 1975 Physics, University of Waterloo, Waterloo, Ontario, Canada**
BSc 1969 Mathematics & Physics, Concordia University, Montreal, Quebec, Canada
 - b. **TEACHING RELATED EXPERIENCE:**
 - i. **Harvard University:** Associate Research Scientist
 - ii. **University of Pennsylvania:** Professor in Material Science and Engineering; Laboratory for Research on the Structure of Materials
 - iii. **Technical Reviewer:** Thin Solid Films and other journals
 - iv. **Invited Lecturer:** Technology Workshops and Presentations at: Cisco, Celestica, Flextronics, Solectron, Jabil, Northrop Grummund, Motorola, Nokia, Raytheon, Boeing; and many other companies.

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Lighting Science Group Corp. v. Cooper Lighting LLC, 1-19-cv-00808 (DDE)

Lighting Science Group Corp. v. MLS Co., Ltd. et al, 1-19-cv-00798 (DDE)

Lighting Science Group Corp. v. Signify N.V. et al, 1-19-cv-00807 (DDE)

ONGOING CASES IN WHICH I ANTICIPATE TESTIFYING AT TRIAL OR BY DEPOSITION:

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