

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

AMPEREX TECHNOLOGY LTD.
Petitioner,

v.

SEMICONDUCTOR ENERGY LABORATORY CO., LTD.
Patent Owner

U.S. Patent No. 11,043,660

Issued: June 22, 2021

Filed: July 8, 2020

Inventor: Teruaki Ochiai et al.

Title: Positive Electrode Active Material Including Lithium Cobaltate Coated with
Lithium Titanate and Magnesium Oxide

Case IPR2023-01349

**PETITION FOR *INTER PARTES* REVIEW
UNDER 35 U.S.C. § 312 AND 37 C.F.R. § 42.104**

TABLE OF CONTENTS

I.	INTRODUCTION	1
II.	MANDATORY NOTICES UNDER 37 C.F.R. § 42.8(B)	2
	A. Real Party-In-Interest	2
	B. Related Matters.....	2
	C. Counsel	3
	D. Service Information	3
III.	PAYMENT OF FEES UNDER 37 C.F.R. § 42.103	3
IV.	CERTIFICATION OF STANDING UNDER 37 C.F.R. § 42.104(A)	3
V.	OVERVIEW OF CHALLENGE AND RELIEF REQUESTED	4
	A. Prior Art References	4
	B. Relief Requested.....	5
VI.	DISCRETIONARY DENIAL IS NOT APPROPRIATE HERE.....	6
	A. The '660 Patent Has Not Been Subject to a Prior Petition	6
	B. The Presented Grounds and Argument Are Dissimilar to the Art and Arguments Previously Presented to the Office	6
	C. The <i>Fintiv</i> Factors Favor Institution	7
	D. There is Compelling Evidence of Unpatentability.....	9
VII.	TECHNOLOGY OVERVIEW.....	9
	A. Lithium-Ion Batteries	9
	B. Strategies to Improve the Cathode	10
	C. Formation of a Fluorine-Containing Layer	12
	D. Crystal Alignment	14

E.	Rock-Salt and Layered Rock-Salt Crystal Structures	15
VIII.	THE '660 PATENT	16
A.	Challenged Claims	17
B.	Specification	17
C.	Prosecution History	18
D.	Person of Ordinary Skill in the Art	20
IX.	CLAIM CONSTRUCTION	20
X.	SPECIFIC GROUNDS FOR PETITION UNDER 37 C.F.R. § 42.104(B)	21
A.	Ground I.A: Claims 1–5 Are Rendered Obvious by Blangero Alone or in Combination with Shim	21
1.	Motivation to Combine Blangero with Shim	21
2.	Independent Claim 1	24
3.	Dependent Claim 2	37
4.	Dependent Claim 3	38
5.	Dependent Claim 4	40
6.	Dependent Claim 5	42
B.	Ground I.B: Claims 6–10 Are Rendered Obvious by Blangero Alone or in Combination with Shim and/or Yamamoto	45
1.	Motivation to Combine Blangero with Yamamoto	45
2.	Independent Claim 6	50
3.	Dependent Claim 7	54
4.	Dependent Claim 8	54
5.	Dependent Claim 9	55
6.	Dependent Claim 10	55
C.	Ground II.A: Claims 1–3 Are Rendered Obvious by Cho Alone or in Combination with Kim	56
1.	Motivation to Combine Cho with Kim	56
2.	Independent Claim 1	60
3.	Dependent Claim 2	71

4.	Dependent Claim 3	73
D.	Ground II.B: Claims 4 And 5 Are Rendered Obvious by Cho Alone or in Combination with Kim and/or Blangero	74
1.	Motivation to Combine Cho with Blangero	74
2.	Dependent Claim 4	76
3.	Dependent Claim 5	77
E.	Ground II.C: Claims 6–8 Are Rendered Obvious by Cho Alone or in Combination with Kim and/or Yamamoto	79
1.	Motivation to Combine Cho with Yamamoto	79
2.	Independent Claim 6	81
3.	Dependent Claim 7	84
4.	Dependent Claim 8	84
F.	Ground II.D: Claims 9 and 10 Are Rendered Obvious by Cho Alone or in Combination with Kim, Yamamoto, and/or Blangero	85
1.	Dependent Claim 9	85
2.	Dependent Claim 10	85
XI.	SECONDARY CONSIDERATIONS	86
XII.	CONCLUSION.....	86

LIST OF EXHIBITS

Exhibit	Description
1001	U.S. Patent No. 11,043,660 (“’660 Patent”)
1002	File History of U.S. Patent No. 11,043,660 (“’660 FH”)
1003	Declaration of Dr. Troy Hayes in Support of <i>Inter Partes Review</i> of U.S. Patent No. 11,043,660
1004	<i>Curriculum Vitae</i> of Dr. Troy Hayes
1005	U.S. Patent Pub. No. 2014/0212759 A1 (“Blangero”)
1006	U.S. Patent Pub. No. 2016/0149215 A1 (“Shim”)
1007	Yamamoto et al., <i>Stabilization of the Electronic Structure at the Cathode/Electrolyte Interface via MgO Ultra-thin Layer During Lithium-ions Insertion/Extraction</i> , 82 <i>Electrochemistry</i> , 891–96 (2014) (“Yamamoto”)
1008	U.S. Patent No. 10,283,770 (“Cho”)
1009	Kim et al., <i>A New Coating Method for Alleviating Surface Degradation of LiNi_{0.6}Co_{0.2}MnO₂ Cathode Material: Nanoscale Surface Treatment of Primary Particles</i> , 15 <i>Nano Lett.</i> , 2111–19 (2015) (“Kim”)
1010	Shim et al., <i>Effects of MgO Coating on the Structural and Electrochemical Characteristics of LiCoO₂ as Cathode Materials for Lithium Ion Battery</i> , 26 <i>Chem. Mater.</i> 2537–43 (2014)
1011	Yu et al., <i>The Investigation of Ti-Modified LiCoO₂ Materials for Lithium Ion Battery</i> , 262 <i>Journal of Power Sources</i> , 136–39 (2014) (“Yu”)
1012	Lee & Park, <i>Interface Characterization of MgF₂-Coated LiCoO₂ Thin Films</i> , 230 <i>Solid State Ionics</i> , 86–91 (2013) (“Lee”)

Exhibit	Description
1013	Ashcroft & Mermin, SOLID STATE PHYSICS, Cengage Learning, 1st ed. (1976)
1014	Int'l Patent No. WO 2013/048048
1015	U.S. Patent No. 9,048,495 B2
1016	CN 102610806 (translated)
1017	U.S. Patent Application 2007/0224506 A1
1018	Dedryvère et al., <i>Surface Film Formation on Electrodes in a LiCoO₂/Graphite Cell: A Step by Step XPS Study</i> , 174 Journal of Power Sources, 462–68 (2007)
1019	Solano, <i>Development of Artificial Surface Layers for Thin Film Cathode Materials</i> , Material Chemistry, Université de Bordeaux (2015)
1020	Aurbach et al., <i>On the Capacity Fading of LiCoO₂ Intercalation Electrodes: The Effect of Cycling, Storage, Temperature, and Surface Film Forming Additives</i> , 47 Electrochimica Acta, 4291–306 (2002)
1021	Aykol et al., <i>Thermodynamic Aspects of Cathode Coatings for Lithium-Ion Batteries</i> , Advanced Energy Materials, 1400690 (2014)
1022	Kitagawa et al., <i>Application of Fluorine-containing Solvents in High Voltage Operation</i> , 78 Electrochemistry, 345–48 (2010)
1023	Sun et al., <i>Role of AlF₃ Coating on LiCoO₂ Particles During Cycling to Cutoff Voltage Above 4.5 V</i> , 156 Journal of the Electrochemical Society, A1005–10 (2009)
1024	Aboulaich et al., <i>High Voltage Stability and Enhanced Electrochemical Performances of LiCoO₂ by CeF₃ Coating</i> , IEEE (2015)

Exhibit	Description
1025	M.C. Rao, <i>Structure and Surface Morphology of LiCoO₂ Thin Film Cathodes Prepared by Pulsed Laser Deposition</i> , 2 J. Intense Pulsed Lasers & Applications in Advanced Physics, 35–38 (2012)
1026	Lu et al., <i>Probing the Origin of Enhanced Stability of “AlPO₄” Nanoparticle Coated LiCoO₂ During Cycling to High Voltages: Combined XRD and XPS Studies</i> , 21 Chem. Mater., 4408–24 (2009)
1027	JP2012-018914 (“Patent Document 1”) (translated)
1028	JP2015-201432 (“Patent Document 2”) (translated)
1029	Wang et al., <i>Infiltrative Coating of LiNi_{0.5}Co_{0.2}Mn_{0.3}O₂ Microspheres with Layer-Structured LiTiO₂: Toward Superior Cycling Performances for Li-ion Batteries</i> , J. Mater. Chem. A (2012)
1030	Xu et al., <i>Lithium Transport Through Lithium-ion Battery Cathode Coatings</i> , 3 J. Mater. Chem. A, 17248–72 (2015)
1031	Bai et al., <i>Performance Improvement of LiCoO₂ by Molten Salt Surface Modification</i> , 167 J. Power Sources, 504–09 (2007)
1032	Shim et al., <i>Synergistic Effects Of Coating and Doping for Lithium Ion Battery Cathode Materials: Synthesis And Characterization Of Lithium Titanate-Coated LiCoO₂ with Mg Doping</i> , Electrochimica Acta 186, 201–08 (2015)
1033	Mizushima et al., <i>A New Cathode Material for Batteries of High Energy Density</i> , Mat. Res. Bull., 783–89 (1980)
1034	Yang et al., <i>Hybrid Microwave Synthesis and Characterization of the Compounds in the Li-Ti-O System</i> , 175 J. Power Sources 1, 575–80 (2008)

Exhibit	Description
1035	Li et al., <i>Lithium Titanate Epitaxial Coating on Spinel Lithium Manganese Oxide Surface for Improving the Performance of Lithium Storage Capability</i> , 6 ACS Appl. Mater. Interfaces 21, 18742–50 (2014)
1036	Eom et al., <i>M₃ (PO₄)₂-Nanoparticle-Coated LiCoO₂ vs LiCo_{0.96}M_{0.04}O₂ (M = Mg and Zn) on Electrochemical and Storage Characteristics</i> , 155 Journal of the Electrochemical Society 3, A201–05 (2008)
1037	Kleykamp, <i>Phase Equilibria in the Li-Ti-O System and Physical Properties of Li₂TiO₃</i> , 61–62 Fusion Engineering and Design, 361–66 (2002)
1038	Bai et al., <i>Performance Improvement of LiCoO₂ by MgF₂ Surface Modification and Mechanism Exploration</i> , 134 Electrochimica Acta, 347–54 (2014)
1039	Katsui et al., <i>Epitaxial Growth of (104)- and (018)-Oriented LiCoO₂ films on MgO Single Crystals Prepared by Chemical Vapor Deposition</i> , 218 Surface and Coatings Technology, 57–61 (2013)
1040	Kumar, A. and Kumar, J., <i>On the Synthesis and Optical Absorption Studies of Nano-Sized Magnesium Oxide Powder</i> , 69 Journal of Physics and Chemistry of Solids 11, 2764–72 (2008)
1041	Declaration of Jennifer Babbitt in Support of <i>Inter Partes</i> Review of U.S. Patent No. 11,043,660
1042	Federal Court Management Statistics (June 2023)
1043	Time to Trial, Virginia Eastern District (September 2, 2018–September 2, 2023), <i>available at</i> https://search.docketnavigator.com/ (last accessed September 2, 2023)

Unless otherwise noted, with respect to these references, all emphasis is added.

Petitioner Amperex Technology, Ltd. (“Petitioner”) requests *inter partes* review (“IPR”) of claims 1–10 (“Challenged Claims”) of U.S. Patent No. 11,043,660 (“’660 Patent”) (Ex. 1001).

I. INTRODUCTION

The ’660 Patent claims a simple, obvious concept: stabilizing lithium-ion batteries by adding known elements to a coating of the battery’s positive electrode active material. Ex. 1001, 13:37–57, 14:8–18. Rechargeable batteries comprise positive and negative electrodes separated by a separator, immersed in an electrolyte solution allowing electrons to flow from the negative electrode to positive electrode as the battery is discharged, thereby providing electricity to an external load. Lithium-ion batteries were already the battery of choice for most portable consumer electronic devices at the time of the alleged invention due to their high energy density.

It was a well-known problem that lithium-ion batteries lose capacity (*i.e.*, ability to hold charge) after repeated charging cycles. It was further well known that adding a coating over the cathode active material could improve the stability of the active material and protect it against hydrofluoric acid that may develop in the battery. The ’660 Patent purports to address this known problem by describing such coatings with specific crystal structures—including “layered rock salt” for the active material (*i.e.*, with an R-3m space group) and “rock salt” for the coating (*i.e.*, with

an Fm-3m space group)—and the orientation between these structures, both well-known concepts. The '660 Patent claims just that: using known coatings and cathode active materials with known crystal structures in a known manner.

As demonstrated herein, the purportedly novel aspects of the '660 Patent were well-known in the prior art and practiced by persons of skill in the art (“POSITA”) before the claimed invention. Petitioner respectfully requests that the Challenged Claims be canceled.

II. MANDATORY NOTICES UNDER 37 C.F.R. § 42.8(b)

A. Real Party-In-Interest

Amperex Technology Ltd. is the real party-in-interest.

B. Related Matters

Petitioner has filed an action for declaratory judgment of non-infringement of U.S. Pat. No. 10,741,828 in the United States District Court for the Eastern District of Virginia (the “Virginia Litigation”). *See Amperex Technology Ltd. v. Semiconductor Energy Laboratory Co., Ltd.*, No. 1:23-cv-272. Patent Owner has answered that complaint with (among others) a counterclaim of infringement of the '660 Patent. That matter may affect, or be affected by, decisions in this proceeding.

C. Counsel

Lead Counsel	Back-Up Counsel
Yimeng Dou (No. 69,770) yimeng.dou@kirkland.com <u>Postal and Hand-Delivery Address:</u> KIRKLAND & ELLIS LLP 555 South Flower Street, Suite 3700 Los Angeles, CA 90071 T: (213) 680-8400 F: (213) 680-8500	W. Todd Baker (No. 45,265) todd.baker@kirkland.com KIRKLAND & ELLIS LLP 1301 Pennsylvania Avenue, N.W. Washington, D.C. 200004 Tel: (202) 389-5000 Fax: (202) 389-5200

D. Service Information

Petitioner concurrently submits a Power of Attorney, 37 C.F.R. § 42.10(b), and consents to electronic service by email at ATL_IPR@kirkland.com.

III. PAYMENT OF FEES UNDER 37 C.F.R. § 42.103

The undersigned authorizes the U.S. Patent and Trademark Office to charge the fee set forth in 37 C.F.R. § 42.15(a)(1) for this Petition to Deposit Account No. 506092. Review of all ten claims is requested. The undersigned further authorizes payment for any additional fees that may be due in connection with this Petition, to be charged to the above-referenced deposit account.

IV. CERTIFICATION OF STANDING UNDER 37 C.F.R. § 42.104(a)

Petitioner certifies that the '660 Patent is available for IPR. Petitioner is not barred or estopped from requesting IPR on the grounds identified herein. Neither Petitioner, nor any party in privity with Petitioner: (1) is the owner of the '660 Patent;

(2) has filed a civil action challenging the validity of the '660 Patent; (3) has been served a complaint alleging infringement of the '660 Patent more than one year prior to the present date; or (4) is estopped from challenging the claims on the grounds identified in the petition. The '660 Patent has not been the subject of a prior IPR or a finally-concluded district court litigation.

V. OVERVIEW OF CHALLENGE AND RELIEF REQUESTED

A. Prior Art References

Petitioner's challenge is based on the following prior-art references.

1. U.S. Patent Application Number 2014/0212759 A1 ("**Blangero**") (Ex. 1005) was filed on May 29, 2012 and published on July 31, 2014 and is prior art under AIA 35 U.S.C. § 102(a)(2).

2. U.S. Patent Application Number 2016/0149215 A1 ("**Shim**") (Ex. 1006) was filed on November 20, 2015, and published on May 26, 2016 and is prior art under AIA 35 U.S.C. § 102(a)(2).

3. Yamamoto et al., *Stabilization of the Electronic Structure at the Cathode/Electrolyte Interface via MgO Ultra-thin Layer During Lithium-ions Insertion/Extraction* ("**Yamamoto**") (Ex. 1007) was published on October 5, 2014 and is prior art under AIA 35 U.S.C. § 102(a)(1).

4. U.S. Patent No. 10,283,770 (“**Cho**”) (Ex. 1008) is a United States Patent effectively filed December 17, 2015, and is prior art under AIA 35 U.S.C. §§ 102(a)(2) and 102(d).

5. Kim et al., *A New Coating Method for Alleviating Surface Degradation of LiNi_{0.6}Co_{0.2}MnO₂ Cathode Material: Nanoscale Surface Treatment of Primary Particles* (“**Kim**”) (Ex. 1009) was published on February 10, 2015, and is prior art under AIA 35 U.S.C. § 102(a)(1).

The above prior-art references predate the ’660 Patent—which claims priority to a foreign application filed on July 5, 2016. Even assuming (solely for purposes of this IPR) that the ’660 Patent is entitled to a July 5, 2016 filing date, the above references are prior art. *See also* Ex. 1041. Blangero and Yamamoto were previously before the Examiner during prosecution, but were not discussed or relied upon in an office action. *See generally* Ex. 1002.

B. Relief Requested

Petitioner requests cancellation of the Challenged Claims as unpatentable under 35 U.S.C. § 103. The specific grounds of the challenge are set forth below, supported by the declaration of Dr. Troy Hayes (Ex. 1003).

Ground	Claims	Proposed Statutory Rejection
I.A	1–5	Obvious over Blangero alone or in combination with Shim

I.B	6–10	Obvious over Blangero alone or in combination with Shim and/or Yamamoto
II.A	1–3	Obvious over Cho, alone or in combination with Kim
II.B	4, 5	Obvious over Cho, alone or in combination with Kim and/or Blangero
II.C	6–8	Obvious over Cho, alone or in combination with Kim and/or Yamamoto
II.D	9, 10	Obvious over Cho, alone or in combination with Kim, Yamamoto, and/or Blangero

VI. DISCRETIONARY DENIAL IS NOT APPROPRIATE HERE

A. The '660 Patent Has Not Been Subject to a Prior Petition

The '660 Patent has not been subject to any prior IPR or PGR petitions. Thus, this is not a “follow-on” petition and there is no basis for the Board to exercise its discretion under 35 U.S.C. § 314(a) and 37 C.F.R. § 42.108(a). *Gen. Plastic Indus. Co. v. Canon Kabushiki Kaisha*, IPR2016-01357, Paper 19 (P.T.A.B. Sept. 6, 2017).

Petitioner has filed only one petition challenging the claims of the '660 Patent, which does not place a substantial and unnecessary burden on the Board. *See* Trial Practice Guide Update (July 2019).

B. The Presented Grounds and Argument Are Dissimilar to the Art and Arguments Previously Presented to the Office

All factors considered by the Board under 35 U.S.C. § 325(d) weigh in favor of institution. *Becton, Dickinson, & Co. v. B. Braun Melsungen AG*, IPR2017-01586, Paper 8 (P.T.A.B. Dec. 15, 2017); *see also Advanced Bionics, LLC v. Med-*

El Elektromedizinische Geräte GmbH, IPR2019-01469, Paper 6 at 8 (P.T.A.B. Feb. 13, 2020). The Board has “held that a reference that ‘was neither applied against the claims nor discussed by the Examiner’ does not weigh in favor of exercising [] discretion under §325(d).” *Fasteners for Retail, Inc. v. RTC Indus., Inc.*, IPR2019-00994, Paper 9 at 7–11 (P.T.A.B. Nov. 5, 2019). The grounds presented herein include obviousness challenges applying Blangero and Cho as base references, which were not applied against the Challenged Claims or discussed by the Examiner during prosecution. The grounds are not cumulative of the references applied during examination because they rely on prior art covering disclosures not found in the references applied during examination. *Bowtech Inc. v. MCP IP, LLC*, IPR2019-00383, Paper 14 at 5 (P.T.A.B. Aug. 6, 2019) (instituting petition where the Examiner did not consider grounds asserted by the petition).

C. The *Fintiv* Factors Favor Institution

The *Fintiv* factors weigh in favor of institution. *See Apple Inc. v. Fintiv, Inc.*, IPR2020-00019, Paper 11 at 6 (PTAB Mar. 20, 2020).

Factor 1 (existence or likelihood of a stay) is neutral. No evidence suggests a stay will not be granted post-institution. The district court proceedings are in their initial stages with no scheduling order, trial date, or answer to the counterclaims.

Factor 2 (proximity of trial date to IPR statutory deadline) weighs in favor of institution. The district court has not set a trial date and has not set any deadlines in

the case. The latest Federal Court Management Statistics (from March 2023) indicate the median time from filing to trial in E.D. Va. is 21.4 months. Ex. 1042, 25. DocketNavigator indicates that the median time to trial for patent cases filed in E.D. Va. in the last five years is 35 months. Ex. 1043. Thus, trial in the Virginia Litigation will likely be later than the projected statutory deadline for a final written decision (March 2025).

Factor 3 (investment in parallel proceeding by court and parties) weighs in favor of institution. As explained above, the parties have invested minimal resources thus far in the parallel district court litigation and are not expected to have invested significant resources by the projected institution date. Petitioner has diligently filed this petition approximately three months after SEL first asserted a counterclaim of infringement of the '660 Patent in the Virginia Litigation and less than two weeks after receiving SEL's amended counterclaims. Institution of this Petition would reduce the substantial expenses that would result from the related litigation.

Factor 4 (overlap between issues) weighs in favor of institution. The '660 Patent has been raised in a counterclaim in the Virginia Litigation. No invalidity issues with respect to the '660 Patent have been raised at the time of filing this Petition. Thus, there is no overlap in issues between this petition and the parallel proceeding.

Factor 5 (same parties): In view of the other *Fintiv* factors, the parties' identities is of limited weight.

Factor 6 (other circumstances impacting discretion) favors institution, as this Petition presents compelling evidence of unpatentability. Considering the guidance set forth in the *Fintiv* Memorandum at 2–4, this IPR should be instituted.

D. There is Compelling Evidence of Unpatentability

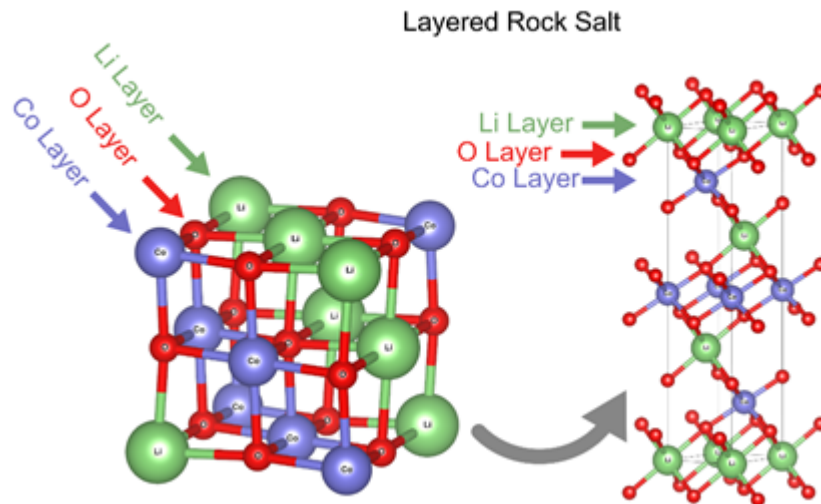
On June 21, 2022, the USPTO Director stated that the Board “will not rely on the *Fintiv* factors to discretionarily deny institution . . . where a petition presents compelling evidence of unpatentability,” which “would plainly lead to a conclusion that one or more claims are unpatentable by a preponderance of the evidence.” As set forth below, this Petition meets those criteria.

VII. TECHNOLOGY OVERVIEW

A. Lithium-Ion Batteries

A lithium-ion battery has four basic components: a negative electrode (anode), a positive electrode (cathode), a separator between those electrodes, and an electrolyte. Lithium-ion batteries typically use microparticles of layered lithium transition metal oxides (*e.g.*, LiCoO₂), as the cathode active material and graphite microparticles as the anode active material. A separator prevents electrical contact between the electrodes while allowing the migration of lithium ions during battery operation. Electrolytes are commonly mixtures of solvents and dissolved lithium salts. Ex. 1003, ¶ 61.

LiCoO_2 is a lithium transition metal oxide capable of reversible lithium extraction and re-insertion with a layered rock-salt structure (shown below):

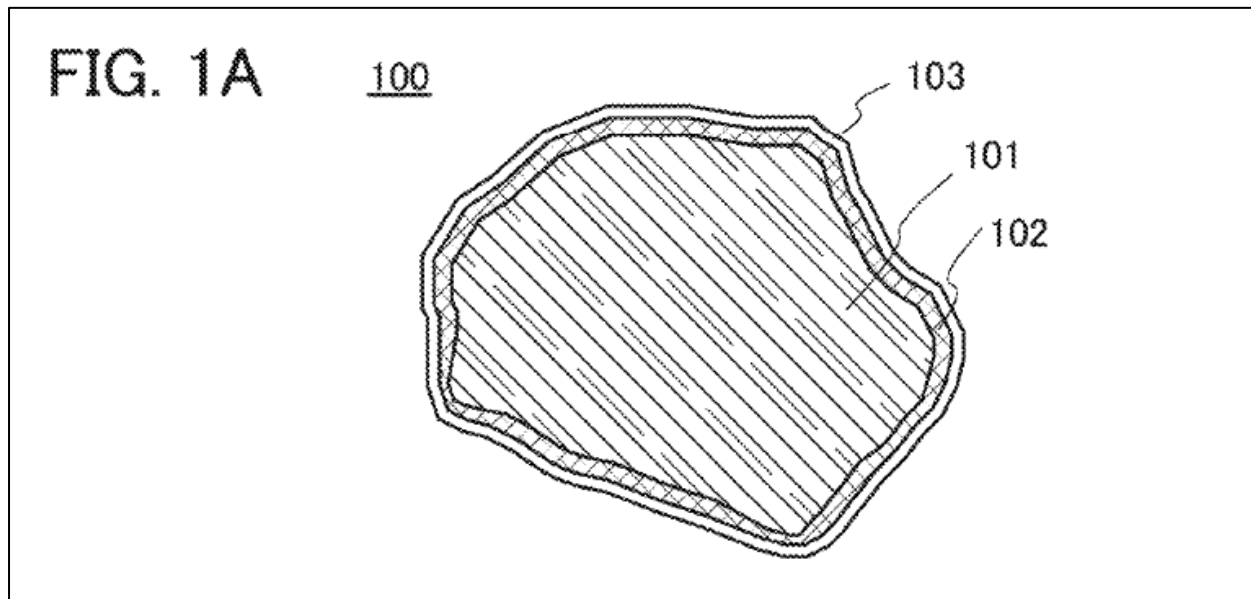


Ex. 1003, ¶ 45. In the cathode, lithium atoms reside in layers between oxygen atoms of the metal oxide. While the battery charges, lithium atoms are removed from the cathode and proceed into the anode. During discharge, lithium ions return to the cathode by the reverse electrochemical process. Ex. 1003, ¶ 62.

B. Strategies to Improve the Cathode

There was (and remains) a desire to make batteries operate at a higher voltage to increase its energy density. However, charging a battery to a point where more than 50% of lithium is removed from LiCoO_2 or in high-temperature conditions decreases the battery's stability. Ex. 1036, 1. Accordingly, researchers have pursued strategies to improve the stability of the positive electrode to allow for higher-voltage operation and longer cycle life.

One common strategy to improve the stability of the cathode is to protect the active material with a coating. As shown by the '660 Patent, a PEAM particle (100) can be divided into the “bulk” (101) and one or more coating layers (102, 103):



Ex. 1001, Fig. 1A. Depending on the coating process and materials, coatings can have different morphologies and thicknesses, such as a rough/patchy coating, a thin uniform coating, or a thicker core-shell structure. A coating layer can mitigate cathode degradation by providing protection from the electrolyte solution, as described below in Section VII.C.

It was known in the art that elements like magnesium, titanium, and fluorine could be used in coating layers. *See* Ex. 1014, [0011]–[0013] (MgF_2 , TiF_3 , and TiF_4 coatings); Ex. 1015, 2:66–3:15 (same); Ex. 1016, 1:24–31 (disclosing one of “Ti, Zr and Hf” used with one of “F or P” on a PEAM surface); Ex. 1017, [0022]–[0023], [0030]. Further, it was known that multiple coating layers could be used in a particle.

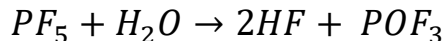
See id., [0027]–[0032], [0077] (“[T]he surface layer is arranged on the coating layer.”).

C. Formation of a Fluorine-Containing Layer

Prior to the '660 Patent, LiPF_6 was known to be a common electrolyte salt for lithium-ion batteries and known to lead to the formation of a fluorine-containing layer on the cathode surface. Ex. 1003, ¶ 61.

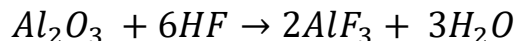
For example, Dedryvère’s 2009 XPS studies revealed an LiF layer on the cathode surface from the hydrolysis of LiPF_6 . Ex. 1018; *see also* Ex. 1019, 86 (fluorine “on the surface” of the cathode particle “caused by the formation of LiF derivatives”); Ex. 1021, 1 (“LiF . . . precipitates on the electrode particles[.]”); Ex. 1020, 11. POSITAs were aware that this fluorine-containing layer was beneficial. For example, Carrillo Solano found that such a surface layer “should protect the cathode from reactions with acidic species in the solution.” Ex. 1019, 35; *see also* Ex. 1022, 3 (fluorine-containing solvent “provides an *electrochemically stable surface film* on a LiCoO_2 cathode and *significantly improves the cycle performance* under a high-voltage condition”).

Moreover, POSITAs would have been motivated to fabricate a fluorine-containing coating on the cathodes to protect against hydrofluoric acid (HF) attack, as it was known that LiPF_6 degrades to form hydrofluoric acid in the presence of moisture, according to these reactions:

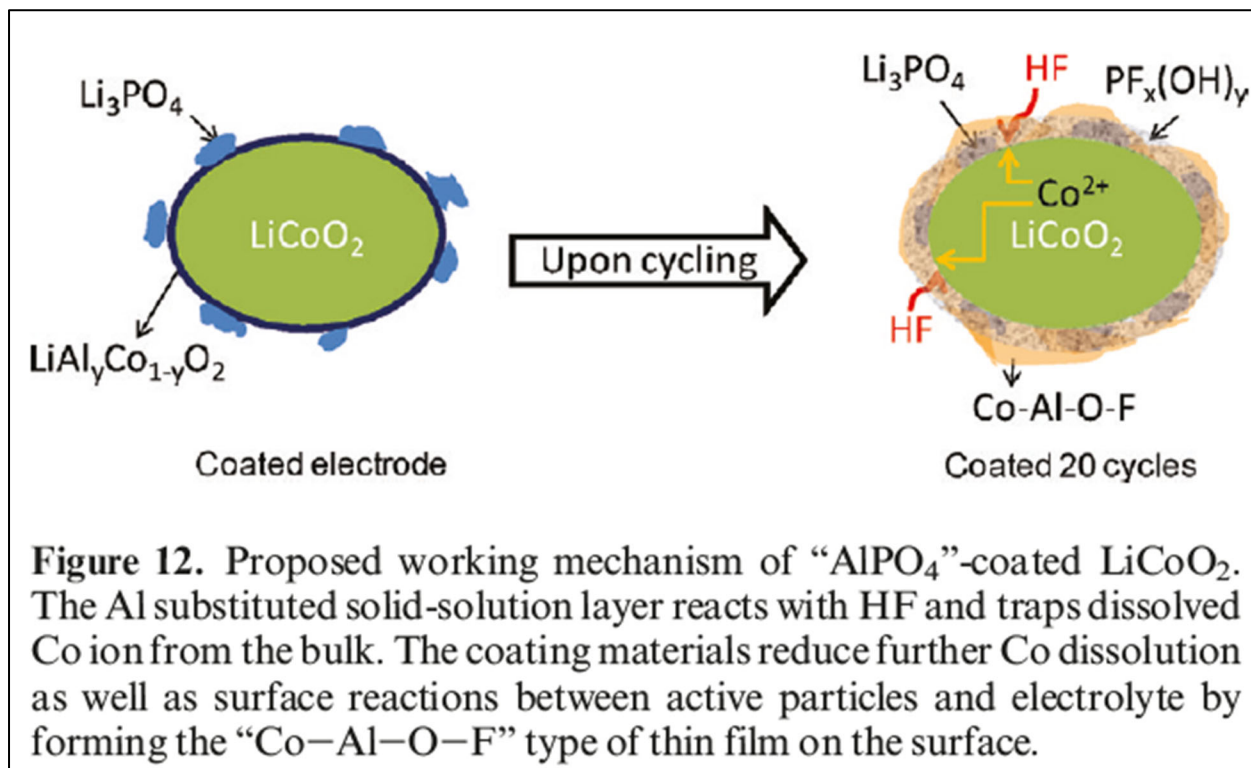


Ex. 1021, 1; Ex. 1036, 4 (describing moisture from cathodes “leading to a continuous increase of HF content”). It was well understood that HF detrimentally affects battery performance. *See* Ex. 1003, ¶ 72; Ex. 1020, 11; Ex. 1021, 1–2; Ex. 1023, 1.

POSITAs with this concern knew to use metal oxide and metal fluoride coatings to protect the cathode, and that metal oxides could scavenge HF to form a metal fluoride layer—particularly advantageous because such a layer would act as a “permanent physical barrier” to HF:



Ex. 1021, 1–2. Indeed, fluoride-containing coatings “serve[] as a protective layer, preventing direct contact with the reactive electrolyte.” Ex. 1012, 4, 6. One study found this fluorine-containing layer to interact with a particle’s coating layer, as shown below:



Ex. 1026, Fig. 12. As shown above, an aluminum phosphate (AlPO₄) coating interacts with a fluorine-containing electrolyte to form a coating comprising Al and O (from the original coating) and fluorine (from the electrolyte). *Id.*, 17 (describing formation of “Al-containing fluoride and/or oxyfluoride species” or “Co-Al-O-F”); *see also* Ex. 1023, 1; Ex. 1024, 2; Ex. 1026; Ex. 1003, ¶ 235.

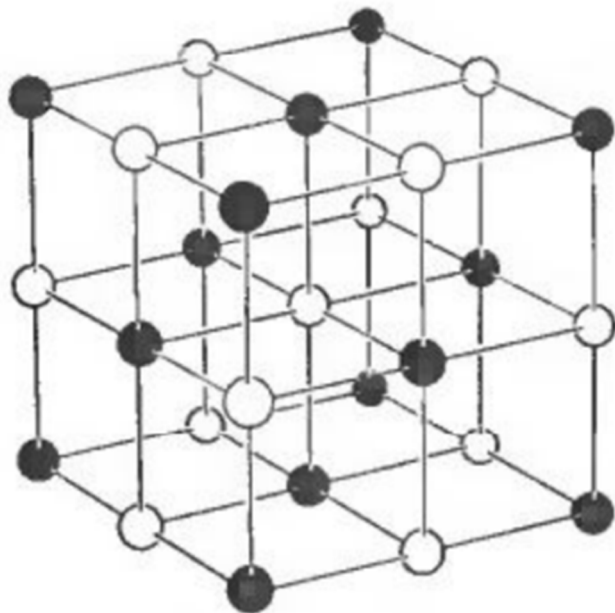
D. Crystal Alignment

To examine interfaces between two crystalline materials, POSITAs knew to characterize the alignment of such crystal structures. One known approach was to use high-resolution transmission electron microscopy (HRTEM) to examine a thin cross-section of a sample rendering visible atomic lattices of both materials. It was further understood that for materials to be well-aligned, the mating crystal planes of

both materials should ideally share the same degree of symmetry and the similar interatomic spacing, and that well-aligned interfaces improved the adhesion and bond strength of the materials. Ex. 1033, 204; Ex. 1035. Moreover, it was apparently understood that coatings could be epitaxially grown on the surface of LiCoO_2 , resulting in good crystallographic alignment between the LiCoO_2 and coating layer. Ex. 1032, 4; Ex. 1039, 2; Ex. 1003, ¶¶ 84–86.

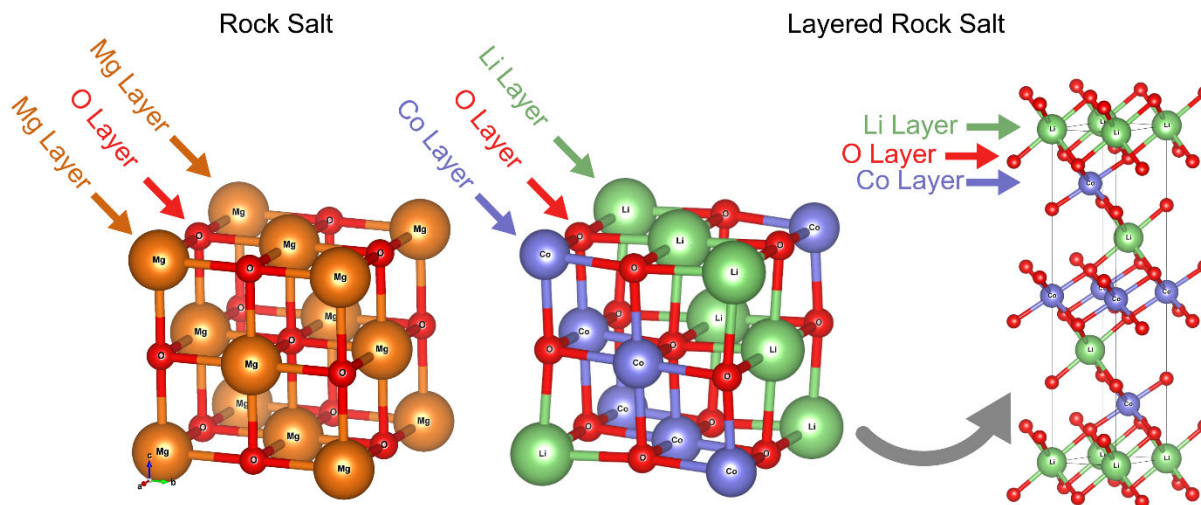
E. Rock-Salt and Layered Rock-Salt Crystal Structures

A rock-salt crystal structure is a common type of crystal structure that many ionic compounds were known to form under typical environmental conditions, including NaCl , LiF , MgO , etc.



Ex. 1013 at 80. These structures comprise alternating cation and anion positions in a 3-D checkerboard pattern classified by the space group $Fm\bar{3}m$. Ex. 1003, ¶ 42.

By contrast, layered rock-salt structures comprise cationic elements alternating along primary diagonals. *Id.*, ¶¶ 43–45. Layered rock-salts are commonly classified as the space group R-3m. Ex. 1025, 1 (“The structure of layered LiCoO_2 has Rhombohedral symmetry and belongs to the space group $R[-]3m[.]$ ”); Ex. 1033. As indicated by the name, layered rock salt “consists of close-packed oxygen ion layers separated by alternating layers of Li and Co ions.” *Id.*; see Ex. 1026, 4. Rock-salt and layered rock-salt structures are shown below (exemplified by MgO and LiCoO_2 respectively):



Ex. 1003, ¶¶ 43–45.

VIII. THE '660 PATENT

The '660 Patent issued on June 22, 2021, from Application No. 16/923,494 (“’494 Application”), filed on July 8, 2020. It claims priority to several Japanese Applications, the earliest of which was filed on July 5, 2016.

A. Challenged Claims

The '660 Patent has ten claims, all of which are challenged by this Petition.

B. Specification

The '660 Patent admits that lithium-ion batteries had been “actively developed” prior to prosecution. '660 Patent, 1:48–50. The '660 Patent addresses a well-known mechanism of battery degradation: “[w]hen charge and discharge cycles are repeated, deformation of the particles of the positive electrode active materials, such as cracking or breaking, might occur.” *Id.*, 4:20–22. The '660 Patent proposes a “coating film” to prevent such deformation, cracking, or breaking. *Id.*, 4:5–8. When the coating film covers a PEAM’s surface, a “decrease in capacity due to charge and discharge cycles can be suppressed.” *Id.*

As the '660 Patent admits, such coating films were known. *See id.*, 1:66–2:2. In particular, the admitted background art includes JP2012-018914 (“Patent Document 1”), which teaches “[t]he formation of the **surface layer** of the positive electrode active material . . . can reduce the energy barrier in insertion and removal of lithium at the positive electrode active material surface.” Ex. 1027, Abstract. Similarly, JP2015-201432 (“Patent Document 2”) discloses a PEAM with “a **surface layer** consisting of a layered structure of lithium cobalt oxide comprising element M (M is Mg and/or Al), and at least a layered structure of lithium cobalt oxide solidified by Ti.” Ex. 1028, Abstract. Further, the '660 Patent admits that its claimed coating

materials were known. Ex. 1001, 22:35–38 (generally known to “synthesiz[e] particles of the composite oxide containing *lithium, cobalt, magnesium, and fluorine*”).

In view of the robust lithium-battery prior art, the '660 Patent describes a narrow purported improvement using different regions inside the PEAM. *Id.*, 2:42–48. For instance, the '660 Patent describes a PEAM including a first region, (preferably LiCoO_2); a second region containing a second transition metal; and a third region containing compound of representative elements in a rock-salt crystal structure—the latter two of which may overlap. *Id.*, 2:49–3:3. Further, “it is preferable that crystal orientations of the first region and the second region be partly aligned with each other and crystal orientations of the second region and the third region be partly aligned with each other.” *Id.*, 3:11–16.

C. Prosecution History

The application leading to the '660 Patent was originally filed with 24 claims. The application received a Non-Final Rejection on September 21, 2020. Ex. 1002 (Part 1), 273–86 (Sep. 21, 2020 Non-Final Rejection). The Examiner rejected all pending claims under 35 U.S.C. §§ 102 and 103 because certain pending claims were anticipated by Liu (CN 102610806 B) and obvious over Liu in view of Gao (US 2016/0104880 A1). *Id.*, 285. The applicant amended certain claims to add (among others) a “positive electrode” with a “first region compris[ing] a layered rock-salt

crystal structure” and a “second region compris[ing] a crystal structure which is different from the layered rock-salt crystal structure.” *Id.* (Part 4), 29–38 (Dec. 21, 2020 Amendment and Reply).

On January 11, 2021, the Applicant received a Final Rejection under § 112. *Id.* (Jan. 11, 2021 Final Rejection). The Examiner found that the specification “[d]id not reasonably provide enablement for a second region comprising a crystal structure which is different from a layered rock-salt crystal structure.” *Id.*, 1311 (Jan. 11, 2021 Final Rejection). The Examiner noted “[t]he limitation ‘wherein the second region comprises a crystal structure which is different from the layered rock-salt crystal structure’ encompasses a second region with any crystal structure.” *Id.*, 1311–12; *see also id.*, 1313–15 (referring to “a crystal orientation of at least a part of the first region and a crystal orientation of at least a part of the second region are substantially aligned.”).

During an Examiner Interview on January 29, 2021 the Applicant proposed canceling certain claims and amending others to include (in relevant part) “wherein a crystal orientation of at least a second part of the first region and a crystal orientation of at least a part of the second region are substantially aligned **with each other.**” *Id.*, 1345 (Feb. 4, 2021 Interview Summary). On February 10, 2021, the Applicant made these changes in a response to the final Office action.

On February 22, 2021, the Examiner issued a Notice of Allowance, indicating that the closest prior art of record, Yura, did not disclose “[a] lithium-ion secondary battery comprising a positive electrode, the positive electrode comprising active material comprising lithium cobaltate in a first region and titanium, magnesium, fluorine, and oxygen in a second region.” Ex. 1002 (Part 4), 109–13.

D. Person of Ordinary Skill in the Art

A POSITA at the time of the ’660 Patent would have at least a bachelor’s degree in chemistry, chemical engineering, or materials science and at least five years of experience in the field of batteries and battery materials. Individuals with different education and additional experience could still be of ordinary skill in the art if that additional experience compensates for a deficit in their education and experience. Ex. 1003, ¶¶ 103–11.

IX. CLAIM CONSTRUCTION

For the purposes of this proceeding only, terms in the challenged claims should be given their plain and ordinary meaning considering the specification and no explicit construction is needed for any terms of the ’660 Patent. If Patent Owner later raises claim constructions, Petitioner reserves the right to respond.

X. SPECIFIC GROUNDS FOR PETITION UNDER 37 C.F.R. § 42.104(B)

A. Ground I.A: Claims 1–5 Are Rendered Obvious by Blangero Alone or in Combination with Shim

1. Motivation to Combine Blangero with Shim

A POSITA would have been motivated to combine Shim’s crystal structures with Blangero’s teachings—and specifically would have understood that the crystal structures of Blangero’s coating layer would resemble those disclosed in Shim. Given Shim and Blangero’s complementary teachings, this combination would have involved routine implementation with no technical risks. Ex. 1003, ¶¶ 127–32.

First, a POSITA would have recognized that Shim and Blangero are directed to improving PEAMs for enhanced battery performance. Both references teach lithium-ion batteries with similar cathode particles (LiCoO_2) treated with the same metals, titanium and magnesium, in a surface layer. Ex. 1006, ¶¶ [0011], [0053], [0056], [0134]; Ex. 1005, ¶¶ [0004], [0005], [0094], [0108]–[0110] (describing particles based on LiCoO_2 doped and coated with Mg and Ti).

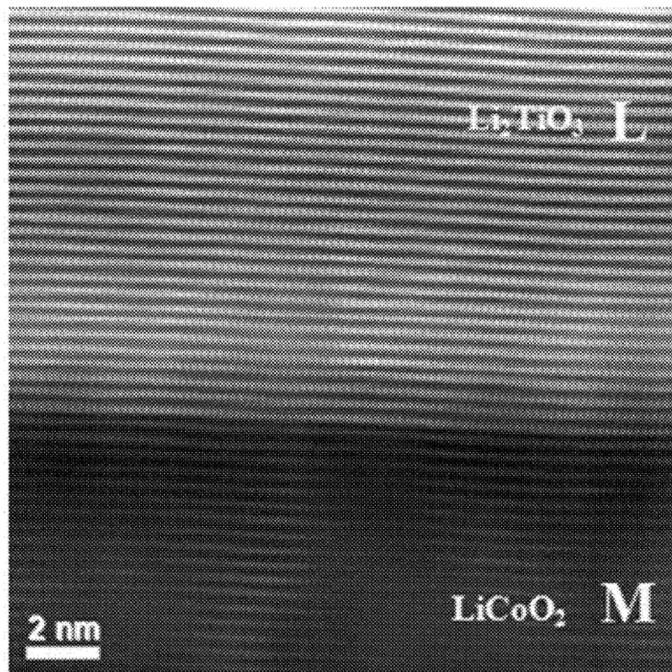
Second, both references address the same problem—improving electrochemical performance of LiCoO_2 batteries—using doping and coating techniques. *See* Ex. 1005, ¶¶ [0004], [0005]–[0007] (coating LiCoO_2 to improve stability while maintaining capacity); Ex. 1006, ¶¶ [0057] (improving “electrical characteristics at the surface of the active material” using Mg- and Ti-containing coating), [0059] (describing “excellent rate capability and cycle-life characteristics”

due to doping), [0060]. Shim teaches various dopants for LiCoO_2 , including “Mg, Al, Ti,” (Ex. 1006, ¶¶ [0019], [0025], [0063]), consistent with Blangero’s N dopants, including Mg and Ti. *See* Ex. 1005, ¶¶ [0004], [0087], [0062], [0109] (describing “state of the art Mg and Ti doped LiCoO_2 ”). A POSITA would have had a reasonable expectation of success in combining Shim’s teachings with Blangero in this way—it was well-known in the art that magnesium and titanium could be added to the bulk of the PEAM via doping. Ex. 1003, ¶ 129. For the same reasons, this combination represents using a “known technique to improve similar devices in the same way,” applying “a known technique” to “a known device ready for improvement” to yield predictable results, and combining known prior-art elements “according to known methods to yield predictable results.” *KSR Int’l Co. v. Teleflex Inc.*, 550 U.S. 398, 417 (2007).

Third, Blangero and Shim provide several reasons why Shim’s teachings regarding its LTO crystal structures apply to Blangero’s similar structures. Blangero’s dopants (Ti and Mg) lead to an “in-situ” coating of a surface layer “enriched in oxidized compounds, like MgO and TiO_2 , that may also be lithiated.” Ex. 1005, ¶¶ [0090], [0094]. Blangero teaches that this “inert coating layer,” which may include Li_2TiO_3 , provides additional safety when the powders are in contact with the electrolyte of the battery.” *Id.*, ¶¶ [0093]–[0094], [0134]. Similarly, Shim teaches a “lithium titanium oxide” (which may be Li_2TiO_3) “positioned on the

surface of the lithium intercalation compound” as a “coating.” Ex. 1006, ¶ [0058]. Like Blangero’s coating, Shim’s coating exhibits “excellent rate capability and cycle-life characteristics during the charge and discharge of the battery.” *Id.*, ¶ [0059]; *see also id.*, ¶¶ [0135], [0117]–[0149]. A TEM image of one of Shim’s PEAMs coated with Li_2TiO_3 is shown below:

FIG. 4B



Id., Fig. 4B, ¶ [0134] (confirming magnesium’s presence in Li_2TiO_3 region); *see also* Ex. 1032, 4 (describing benefits of using LTO coatings including Li_2TiO_3); Ex. 1003, ¶ 130. Crystallographic alignment of a cathode particle and its coating (as shown above) is energetically favorable. *Id.*, ¶ 46.

2. Independent Claim 1

a. *[Preamble]: A lithium-ion secondary battery comprising:*

To the extent the preamble is limiting, Blangero discloses it. Blangero is directed to a “lithium metal oxide powder for use as a cathode material in a rechargeable battery.” Ex. 1005, Abstract; *see also id.*, ¶ [0002] (describing applications of “lithium-ion batteries” including “LiCoO₂-based cathode materials”), ¶ [0008] (“It is an object of the present invention to define a cathode material . . . for high end secondary battery applications.”); Ex. 1003, ¶ 133.

b. *[Element 1.1]: a positive electrode, the positive electrode comprising a positive electrode active material particle comprising lithium cobaltate,*

Blangero discloses this limitation. Lithium cobaltate (also called “lithium cobalt oxide” or “LCO”) refers to LiCoO₂ and is used as a positive electrode active material (or PEAM) in lithium-ion batteries. Ex. 1003, ¶ 134–35; *see also* Ex. 1001, 22:31–33 (referring to lithium cobaltate as LiCoO₂).

Blangero discloses “LiCoO₂-based cathode materials” (Ex. 1005, ¶¶ [0002], [0004]–[0007]), including of the form LiCo_{1-a-b}M'_aM''_bO₂, where 0 < a ≤ 0.05 and 0 < b ≤ 0.02, M' can be one or more elements including magnesium and titanium, and M'' can be fluorine. *Id.*, ¶ [0011]. In fact, Blangero’s enumerated “Examples” all comprise a “LiCoO₂-based cathode material[]” derived from “state of the art titanium and magnesium doped LiCoO₂” referred to as LCO-1 through LCO-4. *Id.*, ¶¶ [0072], [0087], [0108]–[0122]; Ex. 1003, ¶¶ 134–35.

- c. *[Element 1.2]: wherein the positive electrode active material particle comprises a first region and a second region,*

Blangero discloses this limitation by teaching a coating or “surface layer” (second region) over the surface of “LiCoO₂ materials” (first region), noting it was well known to use coatings like Al₂O₃ or LiF to achieve high voltage stability. Ex. 1005, ¶¶ [0006]–[0007]. Blangero’s invention is a “lithium metal oxide powder for use as a cathode material in a rechargeable battery” consisting of two major components: (1) “a core material consisting of the elements Li, a metal M and oxygen,” where M is at least 95% cobalt; and (2) “a surface layer consisting of a mixture of elements of the core material and inorganic N oxide particles,” where N is one or more of a group consisting of magnesium and titanium. *Id.*, ¶ [0009]; *see also id.*, ¶¶ [0010], [0011], [0027], [0059], [0062] (describing MgO, TiO₂, and/or Li₂TiO₃ in the surface layer), [0066], [0094].

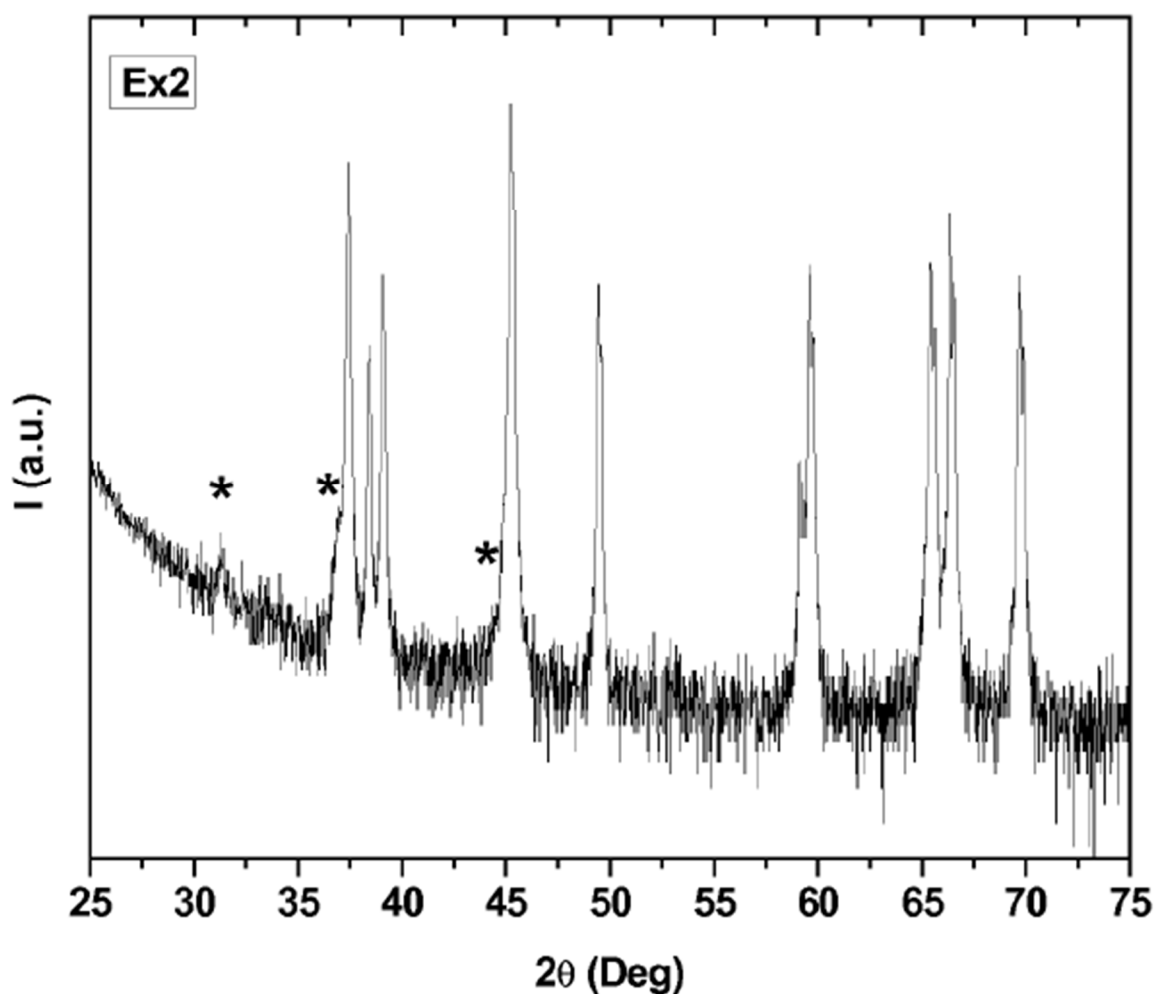
Specifically, Blangero teaches that when “N Dopants such as Mg and Ti” are present in the LiCoO₂ core material, these dopants form an “‘in-situ’ coating” due to “spontaneous segregation of the dopants from the core.” *Id.*, ¶ [0090]. In this case, “Mg and Ti are expelled and accumulated at the surface of the particles,” which “achieve[s] an in-situ coating of the final [LiCoO₂] powder with a layer that is enriched in oxidized compounds, like MgO and TiO₂, that may also be lithiated.” *Id.*, ¶¶ [0090], [0093], [0135]. Blangero teaches that “[t]his inert coating layer

provides additional safety when the powders are in contact with the electrolyte of the battery.” *Id.*, ¶ [0094]; Ex. 1003, ¶¶ 136–37.

d. [Element 1.3]: wherein the first region comprises a layered rock-salt crystal structure,

Blangero discloses this limitation. The ’660 Patent indicates that “layered rock-salt crystal structure” has “space group of . . . R-3m,” as opposed to “space group Fm-3m of a general rock-salt crystal.” Ex. 1001, 8:67–9:3. A POSITA would have known that a LiCoO₂ PEAM has a layered rock-salt structure (R-3m). Ex. 1006, Figs. 4C, 5C, 6C (fast Fourier transform images showing R-3m structure of LiCoO₂); Ex. 1010, 3 (confirming the “hexagonal structure of LiCoO₂ (R-3m)”; Ex. 1025, 1; Ex. 1026, 4–5; Ex. 1003, ¶ 138.

Blangero confirms that its LiCoO₂ first region has a **layered** rock-salt crystal structure with a space group of R-3m: “the core material having a **layered crystal structure** consisting of the elements Li, a metal M and oxygen[.]” Ex. 1005, [0027]; *see also id.*, ¶ [0010] (“The core has a **layered** structure—it is known that lithium cobalt[a]te consists of layers of lithium that lie between slabs or layers of octahedra formed by cobalt and oxygen atoms[.]”). In fact, with respect to Blangero’s Figure 3, that the “main peaks” of the XRD pattern of Blangero’s Example 2 are “attributed to the layered LiCoO₂-based oxide (**R-3m space group**)”:



Id., Fig. 3, ¶ [0126]; *see also id.*, [0060], [0124], [0149]; Ex. 1003, ¶¶ 139–40.

- e. *[Element 1.4]: wherein the second region comprises a rock-salt crystal structure,*

Blangero discloses this limitation. **First**, Blangero discloses that its PEAM material includes a surface layer comprising MgO due to “segregation from the core.” Ex. 1005, [0062]; *see also id.*, [0059] (describing Mg and Ti oxides at a “surface layer”); [0094] (describing a cathode surface layer “enriched in oxidized

compounds like MgO and TiO₂, that may also be lithiated”), ¶ [0133]. A POSITA would have known that at least the MgO portion of Blangero’s coating would have a rock-salt crystal (*i.e.* NaCl) structure:

Table 4.5
SOME COMPOUNDS WITH THE SODIUM CHLORIDE STRUCTURE

CRYSTAL	<i>a</i> (Å)	CRYSTAL	<i>a</i> (Å)	CRYSTAL	<i>a</i> (Å)
LiF	4.02	RbF	5.64	CaS	5.69
LiCl	5.13	RbCl	6.58	CaSe	5.91
LiBr	5.50	RbBr	6.85	CaTe	6.34
LiI	6.00	RbI	7.34	SrO	5.16
NaF	4.62	CsF	6.01	SrS	6.02
NaCl	5.64	AgF	4.92	SrSe	6.23
NaBr	5.97	AgCl	5.55	SrTe	6.47
NaI	6.47	AgBr	5.77	BaO	5.52
KF	5.35	MgO	4.21	BaS	6.39
KCl	6.29	MgS	5.20	BaSe	6.60
KBr	6.60	MgSe	5.45	BaTe	6.99
KI	7.07	CaO	4.81		

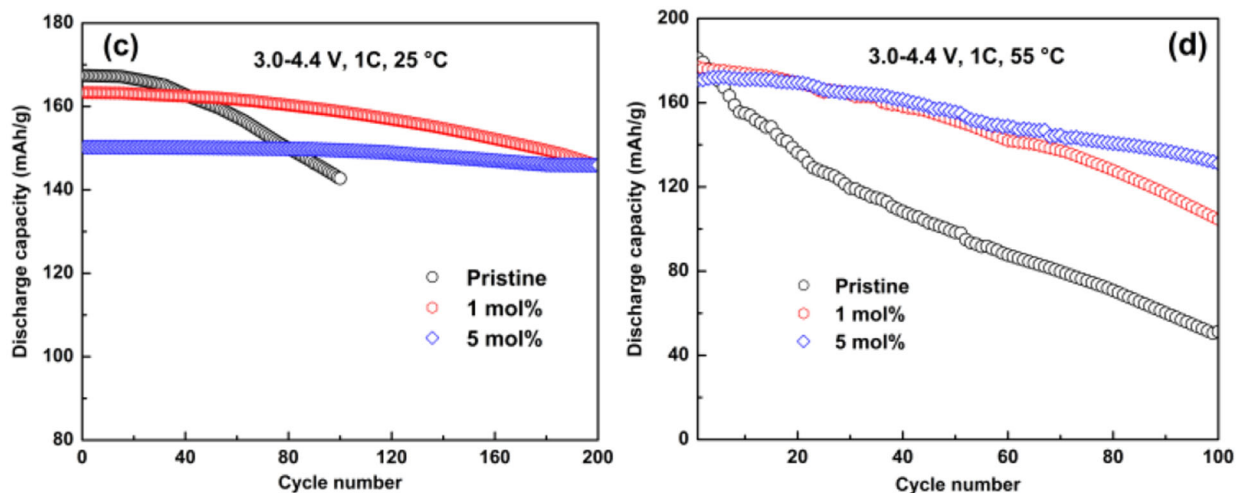
Ex. 1013, 80 (annotated). As one study explains, “the stable phase at room temperature and pressure conditions” of MgO is “a rocksalt cubic structure of NaCl (space group *Fm-3m*).” Ex. 1030, 16; *see also* Ex. 1010, Abstract (“MgO-coated LiCoO₂ delivers a high capacity with excellent retention property.”); Ex. 1031, 3, Fig. 2; Ex. 1040, Fig. 4; Ex. 1003, ¶ 142.

Second, for the same reasons, Blangero’s disclosure of lithium fluoride (LiF) “on the surface” of the particle discloses this limitation. Ex. 1005, ¶ [0011]; *see also id.*, ¶ [0006] (noting that “LiF protective coatings” were well known in the art).

Indeed, as shown in the table above, LiF has rock salt structure. Ex. 1013, 80. Blangero makes clear that such LiF is in the “surface layer” in addition to oxides of magnesium and/or titanium. Ex. 1005, ¶ [0011], cls. 33, 37, 53, 62; Ex. 1003, ¶¶ 141–44.

Third, Blangero renders this limitation at least obvious in view of its surface layer further comprising “TiO₂, that may also be lithiated,” or lithium titanate. Ex. 1005, ¶ [0094]; *see also id.*, ¶¶ [0059], [0062] (surface layer contains different “M, M’, Li, and O elements” including but not limited to Li₂TiO₃). From these disclosures, a POSITA would have found it obvious that Blangero’s particle already included rock salt lithium titanate (*e.g.*, LiTiO₂), or to use such a rock-salt form of lithium titanate which was well known at the time. Indeed, “[r]ock salt-type LiTiO₂,” was found to exhibit “superior structural stability . . . as compared to other Li-Ti-O oxides.” Ex. 1029, 1, 4; Ex. 1034; Ex. 1037; Ex. 1003, ¶¶ 145–46.

A POSITA would have had a reasonable likelihood of success in using rock-salt lithium titanate as a coating to improve lithium-ion battery electrochemical characteristics and cycling stability, as shown in one 2012 study:



Ex. 1029, Fig. 4(c)–(d) (increased cycling performance using rock-salt LiTiO₂ coatings). This study found that rock-salt LiTiO₂ outperformed monoclinic Li₂TiO₃ (which Blangero discloses) in terms of “capacity decay.” *Id.*, 1. the study noted that “*rock salt-type LiTiO₂* can be used as the *suitable candidate of coating materials*.” *Id.*, 5 (“Such impressive cycling performances are attributed to the *robust structure feature of LiTiO₂* protective layer[.]”). Thus, a POSITA would have been motivated to use a rock-salt lithium titanate coating in Blangero’s PEAM to the extent not already included in Blangero’s surface layer. Ex. 1003, ¶¶ 141–46.

f. [Element 1.5]: wherein the second region covers at least a first part of the first region,

Blangero discloses this limitation. As explained above in Section X.A.2.c, Blangero’s PEAM consists of “a core material” (first region) and “a surface layer” (second region). Ex. 1005, ¶ [0009]; *see also id.*, ¶¶ [0010], [0011], [0027], [0059], [0062], [0066], [0094]. In fact, Blangero expressly teaches that the surface layer is an “‘in-situ’ coating” over the first region where the components forming the surface

layer “are expelled” from the core “and accumulated at the surface of the particles.” *Id.*, ¶ [0090]; *see also id.*, ¶¶ [0093], [0135]. Thus, a POSITA would have understood that a “surface layer” covers at least a first part of the core material. Ex. 1003, ¶ 147.

- g. *[Element 1.6]: wherein the positive electrode active material particle comprises titanium, magnesium, fluorine, and oxygen in the second region, and*

Blangero discloses this limitation. As explained above in Section X.A.2.c, Blangero’s PEAM comprises “a surface layer consisting of a mixture of elements of the core material and inorganic N *oxide* particles,” where N is one or more of a group consisting of magnesium and titanium. *Id.*, ¶ [0009]; *see also id.*, ¶¶ [0010], [0011], [0027], [0059], [0062] (describing surface layer containing oxides of magnesium and titanium including but not limited to MgO, TiO₂, and Li₂TiO₃), [0066], [0094]; Ex. 1003, ¶ 148.

Blangero further teaches using fluorine in the surface layer. Ex. 1005, ¶¶ [0011] (“The element[] F . . . may be present on the surface [in] the form of LiF[.]”). Blangero makes clear that such LiF is in the “surface layer” in addition to oxides of magnesium and/or titanium. Ex. 1005, ¶ [0011], cls. 33, 37, 53, 62; Ex. 1003, ¶¶ 149–50.

Further, Blangero's Figure 4(b) (reproduced below) shows "[f]ull scale XPS spectra" of Blangero's Example 1, which is a "titanium and magnesium doped LiCoO_2 " further modified with oxides of magnesium and titanium:

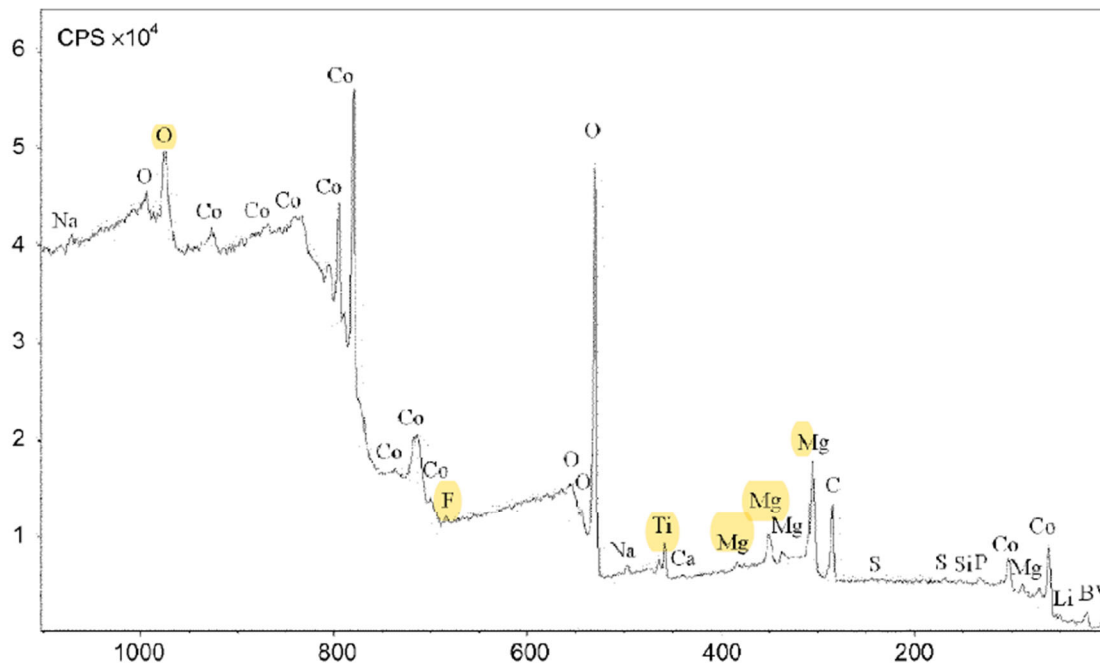


Figure 4(b)

Id., Fig. 4(b) (annotated), ¶ [0129]; *see also id.*, [0094], [0096], [0108]–[0110]. As shown above, Blangero's XPS analysis assigns diffraction peaks consisted with cobalt, oxygen, magnesium, titanium, and fluorine. Thus, for all the above reasons, Blangero discloses titanium, magnesium, fluorine, and oxygen in the second region. Ex. 1003, ¶¶ 148–50.

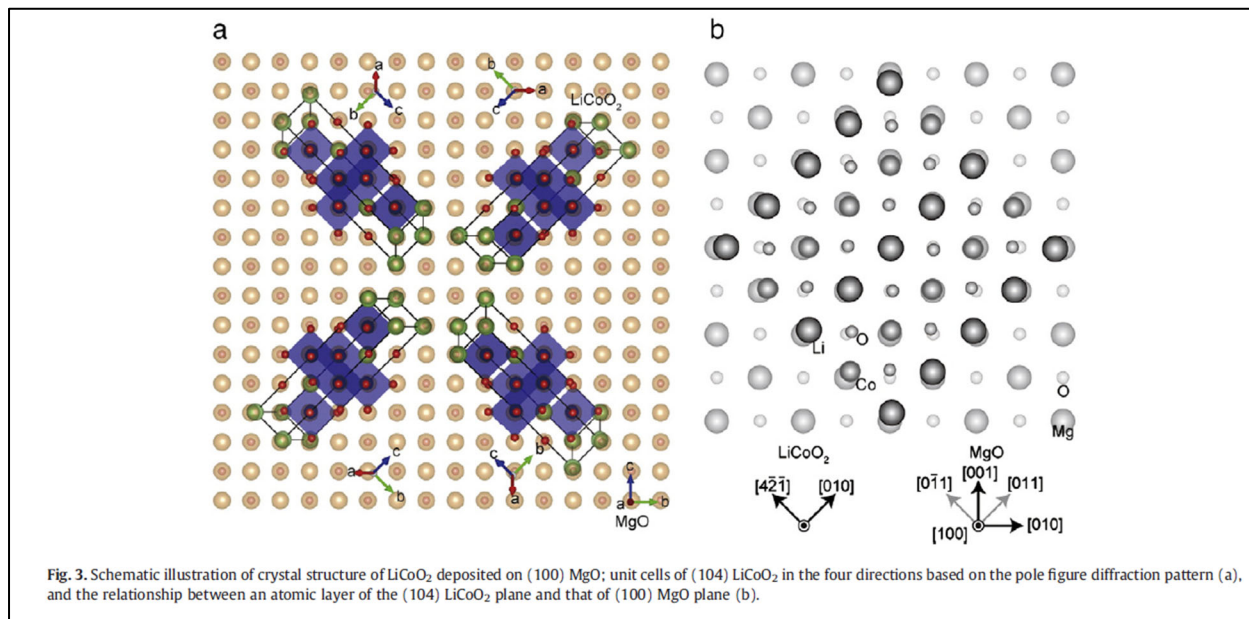
- h. *[Element 1.7]: wherein a crystal orientation of at least a second part of the first region and a crystal orientation of*

at least a part of the second region are substantially aligned with each other.

Blangero renders this limitation obvious either alone (with the knowledge of a POSITA) or in combination with Shim. The '660 Patent explains that “crystal orientations” are “substantially aligned with each other” “where the directions of the cubic closest packed structures formed of anions are aligned with each other” and where “an angle between the repetition of bright lines and dark lines in the layered rock-salt crystal [*i.e.*, first region] and the repetition of bright lines and dark lines in the rock-salt crystal [*i.e.*, second region] is less than or equal to 5°” in a TEM image. Ex. 1001, at 9:7–28.

First, a POSITA would have understood that Blangero’s first region (comprising LiCoO₂) and second region (comprising Li₂TiO₃ and MgO in part) are in substantial alignment due to the principles of epitaxy, which refers to a manner of crystal growth where one crystal layer is formed with an orientation dependent on an underlying crystal layer. Ex. 1003, ¶¶ 151–53. A 2015 paper by the same authors of Shim explains that Li₂TiO₃ (which Blangero teaches) was “epitaxially grown on the surface of LiCoO₂ as a coating layer,” and that the “[001] direction of LiCoO₂ (*c*-axis) was **completely parallel** to the [001] direction of Li₂TiO₃.” Ex. 1032, 4. Other studies have noted that “epitaxial coating may be an ideal strategy for improving the electrochemical performance of cathodes” due to the “the same lattice orientation and small lattice mismatch between the coating layer and the host

material” (*i.e.*, lithium intercalation compound). Ex. 1035, 1, Fig. 3(a) (showing substantial alignment between an LMO cathode material and LTO layer). Similarly, studies have illustrated substantial crystallographic alignment at the interface between MgO and LiCoO₂:



Ex. 1039, Fig. 3 (showing substantial alignment of atomic layers of LiCoO₂ and MgO); *see also id.*, 2 (describing “small” lattice mismatches between LiCoO₂ and MgO which “suggested the hetero-epitaxial growth of LiCoO₂ films on the MgO single-crystal substrates”). A POSITA would have understood that “hetero-epitaxial growth” refers to epitaxial growth between two different materials. Ex. 1003, ¶ 154.

Second, a POSITA would have understood from Shim that Blangero renders this limitation obvious. Shim discloses a coating (*i.e.*, second region) containing Li₂TiO₃ and magnesium (similar to Blangero’s second region) with a crystal

structure in substantial alignment with that of Shim's LiCoO_2 (*i.e.*, first region).

These coating and LiCoO_2 layers are shown below in Shim's Figures 4B and 5B:

FIG. 4B

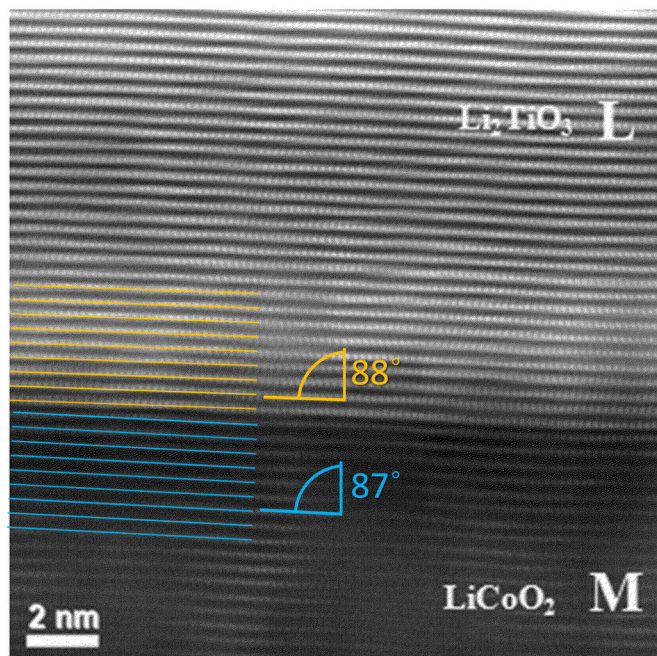
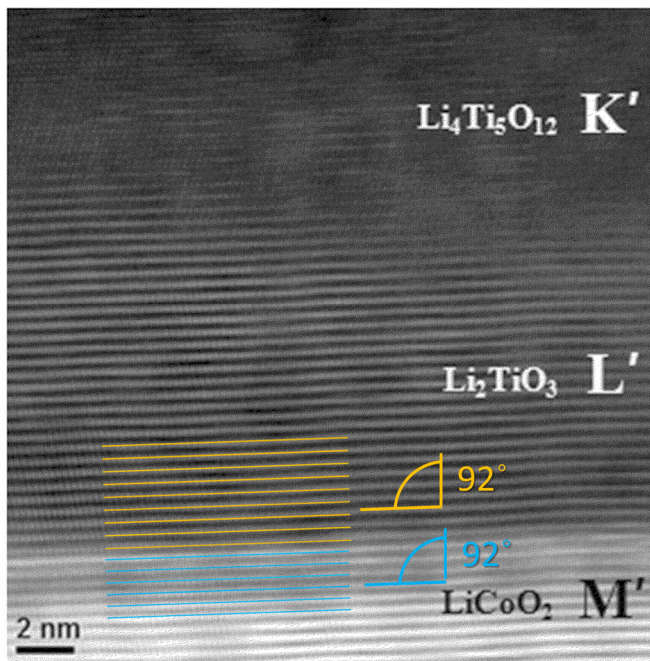


FIG. 5B



Ex. 1006, Figs. 4B, 5B (annotations added). As shown above, the angles between the lines in the coating regions and the lithium intercalation regions measure approximately 1° and 0°, respectively, thereby indicating that Shim's first and second regions are substantially aligned. Ex. 1003, ¶¶ 155–56. A POSITA would have also understood that Shim's teachings of substantial alignment between crystal orientations of the first and second regions would apply equally to Blangero's first and second regions for the reasons described above in Section X.A.1. Additionally, for the same reasons, a POSITA would have been motivated to use Shim's Li_2TiO_3 coating layer in Blangero's particle, as this coating layer would be in substantial

alignment with Blangero's LiCoO₂ layer. Indeed, the crystallographic alignment of a cathode particle and its coating is energetically favorable. *Id.*, ¶ 46.

For the above reasons, a POSITA would have found this limitation obvious, either in view of Blangero alone or with the knowledge of a POSITA and/or Shim. *Id.*, ¶ 151–56.

3. Dependent Claim 2

- a. *[Element 2.0]: The lithium-ion secondary battery according to claim 1,*

Blangero, alone or with Shim, renders claim 1 obvious. *See supra*, § X.A.2.

- b. *[Element 2.1]: wherein the titanium, the magnesium, the fluorine, and the oxygen are provided in a range from the surface of the positive electrode active material particle to a depth of 5 nm.*

Blangero discloses titanium, magnesium, fluorine, and oxygen provided in a range from the surface of the PEAM particle to a depth of 5 nm. As explained above, Blangero discloses a surface layer containing these four elements. *See supra*, §§ X.A.2.e, X.A.2.g. Blangero further discloses that “[t]he surface layer is typically between 20 nm to 200 nm, and preferably between 20 nm and 100 nm thick.” Ex. 1005, ¶ [0066]; *see also id.*, cl. 36 (“wherein the thickness of the surface layer is less than 100 nm”). Moreover, as shown in Table 3 below, Blangero's XPS analysis indicates titanium, magnesium, fluorine, and oxygen were all found at “the surface” of Example 1:

TABLE 3

elemental composition of the surface
of the grains of LCO-1 and Ex1.

at. %	LCO-1	Ex1
Li	21.7	15.3
Co	8.7	12.0
O	41.9	37.5
C	23.1	26.5
S	1.3	0.8
Ca	0.6	0.1
F	0.9	0.4
Ti	0.9	1.1
Na	0.3	0.3
Si	Below detection limit	1.1
P	0.4	0.6
Mg	Below detection limit	4.4

Id., Table 3; *see also* Ex. 1001, 19:10–17 (XPS used to characterize element presence from surface to 5 nm). Thus, a POSITA would have understood that the titanium, magnesium, fluorine, and oxygen present in the surface layer would be found within the first 5 nm from the surface of the particle. Ex. 1003, ¶ 158–59.

4. Dependent Claim 3

- a. *[Element 3.0]: The lithium-ion secondary battery according to claim 1,*

Blangero, alone or with Shim, renders claim 1 obvious. *See supra*, § X.A.2.

- b. *[Element 3.1]: wherein the positive electrode further comprises a conductive additive, and*

Blangero renders this limitation obvious. Blangero’s PEAM particles have “low electrical conductivity” which aids in “preventing undesirable side-reactions.” Ex. 1005, ¶¶ [0062], [0065], [0092], [0094]. However, a POSITA would have recognized that a conductive agent would have been necessary in Blangero’s particle

to overcome this low electrical conductivity, as “it is commonly accepted that high electrical conductivity is needed for the Li⁺ cation diffusion within the solid cathode and across the interface between electrolyte and cathode.” *Id.*, [0091]. A POSITA would have understood that conductive additives were, and still are, found in nearly all (if not all) lithium-ion battery cathodes. Ex. 1003, ¶ 161.

Alternatively, and for the same reasons, Blangero and Shim render this limitation obvious. Shim discloses “the positive active material layer further includes . . . ***a conductive material.***” Ex. 1006, ¶ [0081]. “Any suitable electrically conductive material may be used as the conductive material” which “is included to provide electrode conductivity.” *Id.*, ¶ [0083]. Additionally, a POSITA would have been motivated to combine Shim’s conductive material with Blangero’s positive electrode for all the reasons explained above in Section X.A.1. Ex. 1003, ¶ 161–63.

- c. *[Element 3.2]: wherein the conductive additive comprises carbon fiber, graphene or multilayer graphene.*

Blangero, alone or with Shim, renders this limitation obvious. As explained above in Section X.A.4.b, a POSITA would have known to use a conductive additive in Blangero’s particle. A POSITA would have further understood that carbon fiber, graphene, and multilayer graphene were widely known, understood, and used in the art as conductive additives, and were even referenced in the prosecution of the ’660 Patent. Ex. 1002 (Part 1), 285 (citing Gao (US 2016/0104880 A1)); Ex. 1008; Ex. 1003, ¶ 164.

Alternatively, Blangero and Shim render this limitation obvious. Shim explains that “[a]ny suitable electrically conductive material may be used as the conductive material” including “a carbon-based material such as *natural graphite, artificial graphite . . . a carbon fiber, and/or the like.*” Ex. 1006, ¶ [0083]. Moreover, a POSITA would have found using “graphene” and “multilayer graphene” obvious from Shim, as “graphite” (whether natural or artificial) is composed of many layers of graphene. Ex. 1003, ¶¶ 164–65. A POSITA would have been motivated to use these specific conductive additives for all the reasons described above in Sections X.A.1 and X.A.4.b.

5. Dependent Claim 4

- a. *[Element 4.0]: The lithium-ion secondary battery according to claim 1,*

Blangero, alone or with Shim, renders claim 1 obvious. *See supra*, § X.A.2.

- b. *[Element 4.1]: wherein a relative value of a concentration of the titanium is greater than or equal to 0.05 and less than or equal to 0.4 when the surface of the positive electrode active material particle is subjected to an XPS analysis and a concentration of cobalt is defined as 1.*

Blangero discloses this element—specifically, Blangero teaches a Ti:Co concentration ratio at the surface of the PEAM particle in the claimed range.

Blangero teaches a “cathode material in a rechargeable battery” comprising a core material (*i.e.*, doped LiCoO₂) and a “surface layer” comprising elements of the core material and “one or more metals” including magnesium and titanium. Ex.

1005, ¶¶ [0009], [0072], [0091], [0093], [0094], [0108]. Blangero’s Example 1 is a particle comprising a “LiCoO₂-based cathode” and an “electron insulating surface” containing lithium, cobalt, and “metal oxides comprising Mg and Ti.” *Id.*, ¶ [0108]. Blangero specifically compares the particle of Example 1 against its LiCoO₂ “parent” (“LCO-1”). *Id.*, ¶¶ [0108]–[0110].

As shown below in Table 3, Blangero investigated “[t]he chemical composition of the surfaces of the LCO-1 and Ex1” “by means of XPS”:

TABLE 3		
elemental composition of the surface of the grains of LCO-1 and Ex1.		
at. %	LCO-1	Ex1
Li	21.7	15.3
Co	8.7	12.0
O	41.9	37.5
C	23.1	26.5
S	1.3	0.8
Ca	0.6	0.1
F	0.9	0.4
Ti	0.9	1.1
Na	0.3	0.3
Si	Below detection limit	1.1
P	0.4	0.6
Mg	Below detection limit	4.4

Id., ¶ [0129] (Table 3) (annotated); *see also id.*, Fig. 4 (showing XPS spectra for Example 1). At Example 1’s surface, the Ti:Co ratio is 1.1/12.0, which equals 0.0917—which falls within the claimed range of 0.05 to 0.4, rendering this element obvious. *See Merck & Co. v. Biocraft Lab’ys., Inc.*, 874 F.2d 804, 809 (Fed. Cir. 1989) (claimed ranges do not defeat obviousness where “experimentation needed to

arrive at the claimed [ranges] was nothing more than routine”); *see also* Ex. 1011, 3, Table 3 (showing similar Ti:Co ratio of 0.0849 at the surface of a doped LiCoO₂ particle); Ex. 1003, ¶¶ 167–71.

Additionally, a POSITA would have understood that the Ti:Co concentration ratio is a result-effective variable because it was known that titanium “effectively improve[s] the electrochemical performance of the LiCoO₂ material.” Ex. 1011, 4. But a POSITA would also know to use as little titanium as necessary for this improvement, understanding that titanium does not participate in the electrochemical reaction and is present at the expense of cobalt, which is electrochemically active and contributes to the battery’s capacity. Ex. 1003, ¶¶ 167–71. Thus, the optimum range of Ti:Co concentration ratios could have been discovered by routine experimentation. *In re Applied Materials*, 692 F.3d 1289, 1295 (Fed. Cir. 2012) (“[I]t is not inventive to discover the optimum or workable ranges by routine experimentation,” if the parameter is known to be a result-effective variable) (quoting *In re Aller*, 220 F.2d 454, 456 (CCPA 1955)).

6. Dependent Claim 5

- a. *[Element 5.0]: The lithium-ion secondary battery according to claim 1,*

Blangero, alone or with Shim, renders claim 1 obvious. *See supra*, § X.A.2.

- b. *[Element 5.1]: wherein a relative value of a concentration of the magnesium is greater than or equal to 0.4 and less than or equal to 1.5 when the surface of the positive*

electrode active material particle is subjected to an XPS analysis and a concentration of cobalt is defined as 1.

Blangero renders this element obvious. A POSITA would have understood that Blangero's particle would have had a Mg:Co concentration ratio in the claimed range.

As explained above in X.A.2, Blangero teaches an LiCoO₂-based particle (Example 1) containing a surface layer comprising oxides of titanium and magnesium. Ex. 1005, ¶¶ [0009], [0072], [0091], [0093], [0094], [0108]. As shown below, Blangero's XPS analysis indicates that, at the surface of the particle of Example 1, the Mg:Co ratio is 4.4/12.0, which equals 0.367:

TABLE 3		
elemental composition of the surface of the grains of LCO-1 and Ex1.		
at. %	LCO-1	Ex1
Li	21.7	15.3
Co	8.7	12.0
O	41.9	37.5
C	23.1	26.5
S	1.3	0.8
Ca	0.6	0.1
F	0.9	0.4
Ti	0.9	1.1
Na	0.3	0.3
Si	Below detection limit	1.1
P	0.4	0.6
Mg	Below detection limit	4.4

Id., ¶ [0108], Table 3; *see also id.*, Fig. 4(b). This ratio approaches the claimed range of 0.4 to 1.5, rendering this element obvious. Further, Blangero's Example 2 is made

with 20% more magnesium compared to Example 1 (*see id.*, ¶¶ [0110]–[0111]), further indicating that the claimed range would be obvious. Ex. 1003, ¶ 173.

Indeed, a claimed range does not allow a claim to survive invalidation over obviousness where “experimentation needed to arrive at the claimed [ranges] was nothing more than routine.” *See Merck*, 874 F.2d at 809. In *Aller*, the CCPA found that a claim reciting a sulfuric acid concentration range between 25 and 70% and a temperature range between 40 and 80° C was rendered obvious by a reference discussing a similar process with a 10% sulfuric acid solution at 100° C. *Aller*, 220 F.2d at 459 (affirming obviousness rejection because “the claimed process is merely different in degree and not in kind from the reference process”). Ex. 1003, ¶¶ 173–77.

Here, a POSITA would have known that magnesium improves performance of LiCoO₂-based batteries, including improved rate capability, cycle-life characteristics, and protection of the cathode active material from unwanted interactions with the electrolyte. Ex. 1006, ¶ [0059]; Ex. 1005, ¶¶ [0093]–[0094]. Although magnesium is not electrochemically active, a POSITA would have been motivated to use enough magnesium to effect these benefits. Thus, a POSITA would have understood that the Mg:Co concentration is a result-effective variable whose optimum range could have been discovered by routine experimentation. *See Applied Materials*, 692 F.3d at 1295. A POSITA would have known of other studies showing

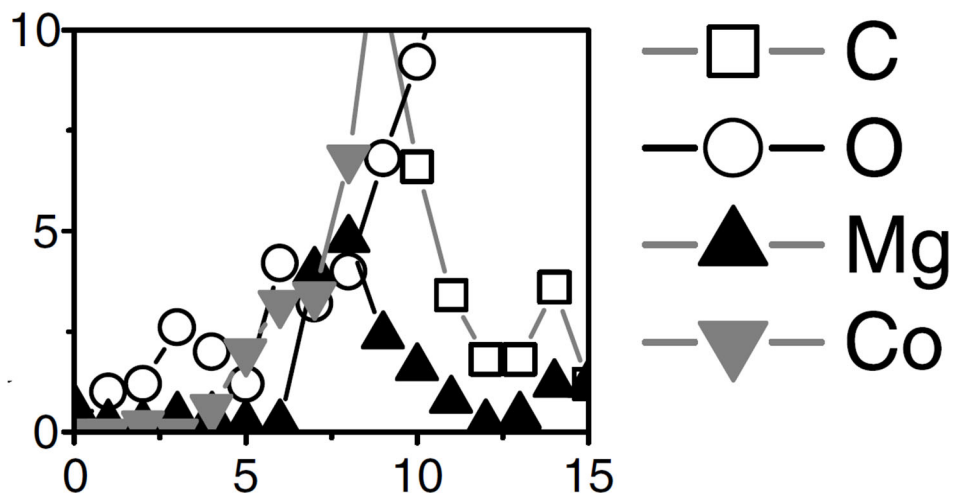
Mg:Co concentration ratios within the claimed range, further indicating that Mg:Co concentration is a matter of routine experimentation. *See* Ex. 1012, Fig. 5(a) (showing Mg:Co ratio of 1.25 at the surface of a coated LiCoO₂ particle); Ex. 1003, ¶¶ 173–77.

B. Ground I.B: Claims 6–10 Are Rendered Obvious by Blangero Alone or in Combination with Shim and/or Yamamoto

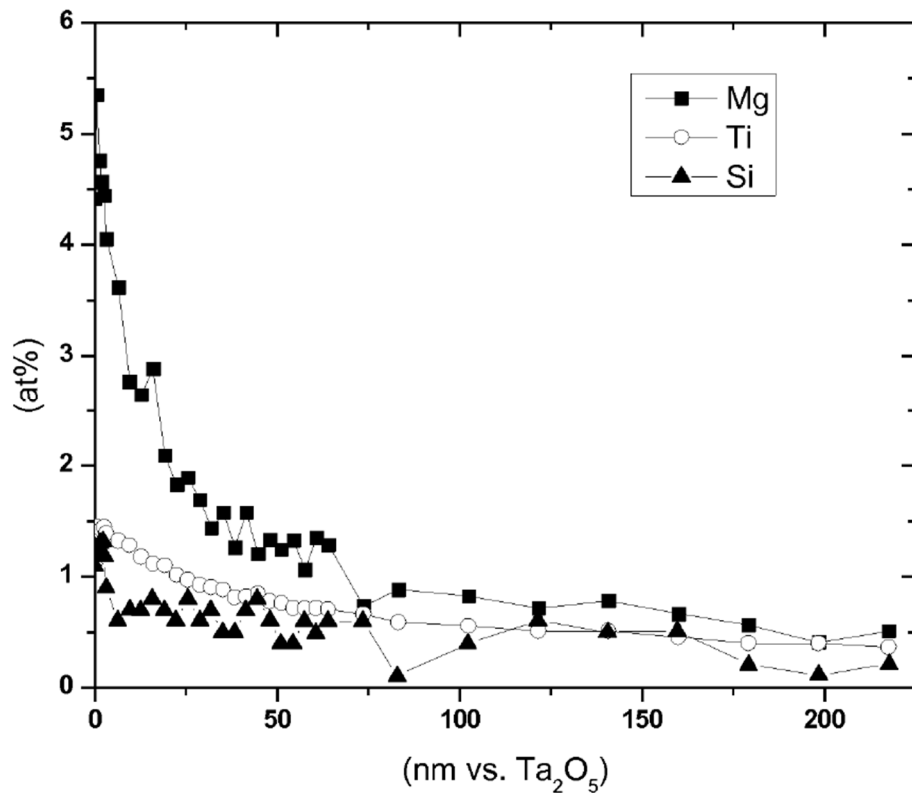
1. Motivation to Combine Blangero with Yamamoto

A POSITA would have been motivated to combine Yamamoto’s teachings—*e.g.*, characterizing magnesium concentration through a particle using EDX line scans to show that the particle’s second region extends to a depth where magnesium concentration reaches 1/5 of its peak—in Blangero’s particle. Given Blangero and Yamamoto’s complementary teachings, this combination would have involved routine implementation with no technical risks. Ex. 1003, ¶¶ 178–85.

First, Yamamoto teaches a simple concept—that “a Mg containing layer of approximately 5 nm in thickness” (*i.e.*, MgO) experiences a concentration peak within that 5 nm range, as observed through an EDX line scan:



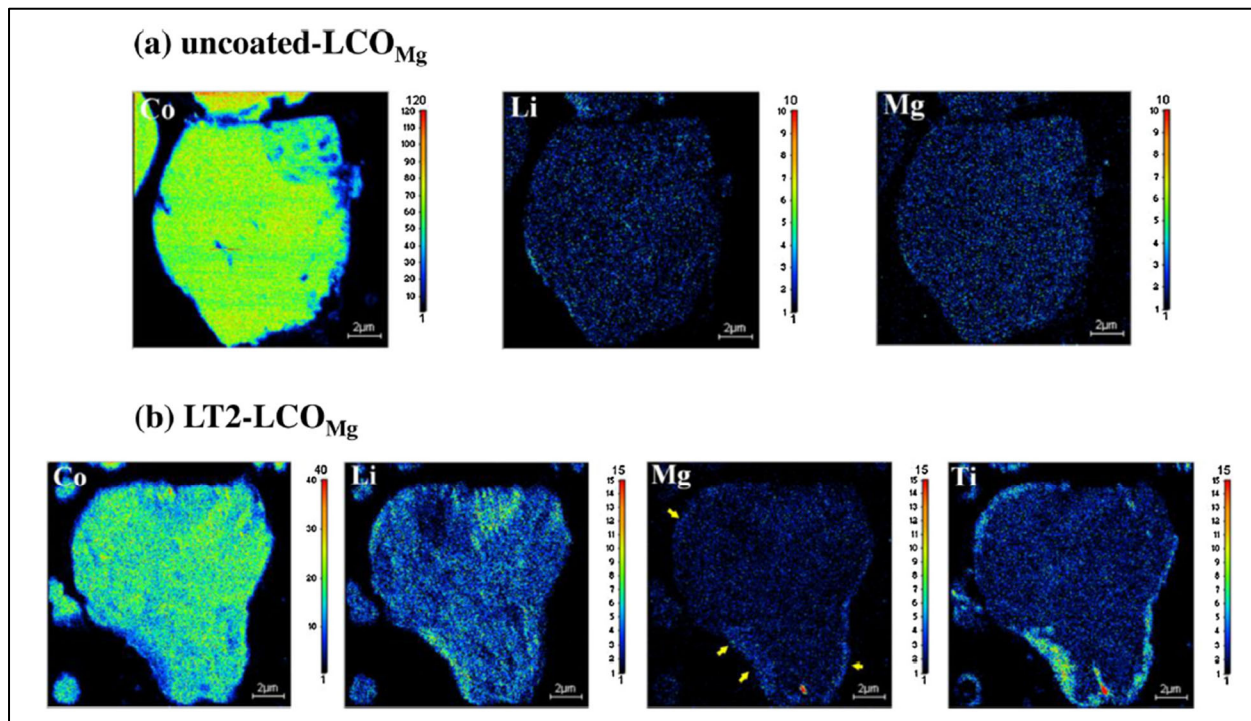
See Ex. 1007, 2, Fig. 1(b). A POSITA would have understood that magnesium concentration decreases towards the bulk of the particle, away from the coating, and that, at some given depth, the concentration of magnesium will be 1/5 of its maximum concentration. Ex. 1003, ¶¶ 179–80. Blangero corroborates Yamamoto’s EDX line scan analysis, showing that the concentration of magnesium would decrease from the surface of the coating (*i.e.*, second region), toward the center of the PEAM. Specifically, Blangero shows that the concentration of magnesium peaks at the surface (0 nm depth) of a coated LiCoO_2 particle at ~5.4 atomic %, and that its concentration decreases to ~1 at% “over the first 50 nm of the particle[]”:



Ex. 1005, Fig. 8, ¶ [0135]. Blangero confirms that “[t]he surface layer” is “preferably between 20 nm and 100 nm thick” (*id.*, ¶ [0066]), which is the approximate depth range where magnesium concentration reaches ~1 at%. In fact, Blangero teaches that the concentration of magnesium at the surface “is at least 5 times” its concentration in the bulk. *Id.*, ¶ [0011]. This corroborates Yamamoto’s teaching that magnesium concentration decreases to 1/5 of its peak value throughout the second region. Ex. 1003, ¶ 181.

Second, a POSITA would have been motivated to use Yamamoto’s magnesium concentration profile in Blangero. Specifically, a POSITA would have understood that Blangero’s beneficial “in-situ” coating is the result of a similar

concentration profile due to “segregation of dopants [*i.e.*, magnesium and titanium] from the core.” Ex. 1005, ¶¶ [0090], [0094]. In fact, it was known that when LiCoO₂ PEAMs are doped with magnesium ions, “the doped ions (Mg²⁺) from the active materials move to the coating layer.” Ex 1032, 1. Blangero confirms this: “[t]he surface is enriched of elements N such as Mg [and] Ti” and “formed by segregation from the core and accumulation of these metal dopants at the surface of the particles. In the core, these dopants are substantially absent.” Ex. 1005, ¶ [0062]; *see also id.*, ¶ [0090]. Other researchers specifically observed this process in Mg-doped LiCoO₂ coated with lithium titanate. Ex. 1032, 3. The STEM images below show that magnesium is uniformly distributed in an uncoated LiCoO₂ PEAM and is segregated to the surface in LT2-LCO_{Mg} PEAMs not otherwise coated with Mg:



Ex. 1032, Fig. 2. Accordingly, a POSITA would have further understood that Blangero's Mg-doped PEAMs would have a peak of magnesium near the surface that decreases in a depth direction towards a depth where magnesium concentration is 1/5 of its maximum, as shown in Blangero's Figure 8, thus forming the "in-situ" coating layer. Ex. 1005, Fig. 8, ¶¶ [0011], [0090], [0094], [0135]; Ex. 1003, ¶¶ 182–83.

Third, Blangero and Yamamoto address the same problem—improving electrochemical performance of LiCoO_2 batteries—using similar coatings. Yamamoto's coating, MgO, is one of the components of Blangero's surface layer. See Ex. 1005, ¶¶ [0032], [0062], [0092]; Ex. 1007, 1 ("The MgO coating improves the durability of the cathode during high-potential cycling."); see *supra*, § X.A.2.e. In fact, Blangero expressly states that its "inert coating layer" "that is enriched in oxidized compounds, like MgO" "provides additional safety when the powders are in contact with the electrolyte of the battery." Ex. 1005, ¶¶ [0094]. Ex. 1003, ¶ 184.

Fourth, a POSITA would have recognized that both Blangero and Yamamoto are directed to improving PEAMs for enhanced battery performance. To this end, both references teach coating LiCoO_2 active materials with compounds containing magnesium and oxygen to attain this specific benefit. See Ex. 1005, ¶¶ [0032], [0062], [0071]–[0072], [0092], [0108]–[0121] (describing treating enumerated Examples and precursor LCO compounds alike with magnesium—including with

reference to “state of the art titanium and magnesium doped LiCoO₂”); Ex. 1007, 1 (“The MgO coating improves the durability of the cathode during high-potential cycling. . . . [T]he MgO coating suppresses drastic distortions of local structure at the LiCoO₂ surface.”). Ex. 1003, ¶¶ 178–85.

2. Independent Claim 6

a. *[Preamble]: A lithium-ion secondary battery comprising*

To the extent the preamble is limiting, Blangero discloses it. *See supra*, § X.A.2.a.

b. *[Element 6.1]: a positive electrode, the positive electrode comprising a positive electrode active material particle comprising lithium cobaltate,*

Blangero discloses this limitation. *See supra*, § X.A.2.b.

c. *[Element 6.2]: wherein the positive electrode active material particle comprises a first region and a second region,*

Blangero discloses this limitation. *See supra*, § X.A.2.c.

d. *[Element 6.3]: wherein the first region comprises a layered rock-salt crystal structure,*

Blangero discloses this limitation. *See supra*, § X.A.2.d.

e. *[Element 6.4]: wherein the second region comprises a rock-salt crystal structure,*

Blangero discloses this limitation. *See supra*, § X.A.2.e.

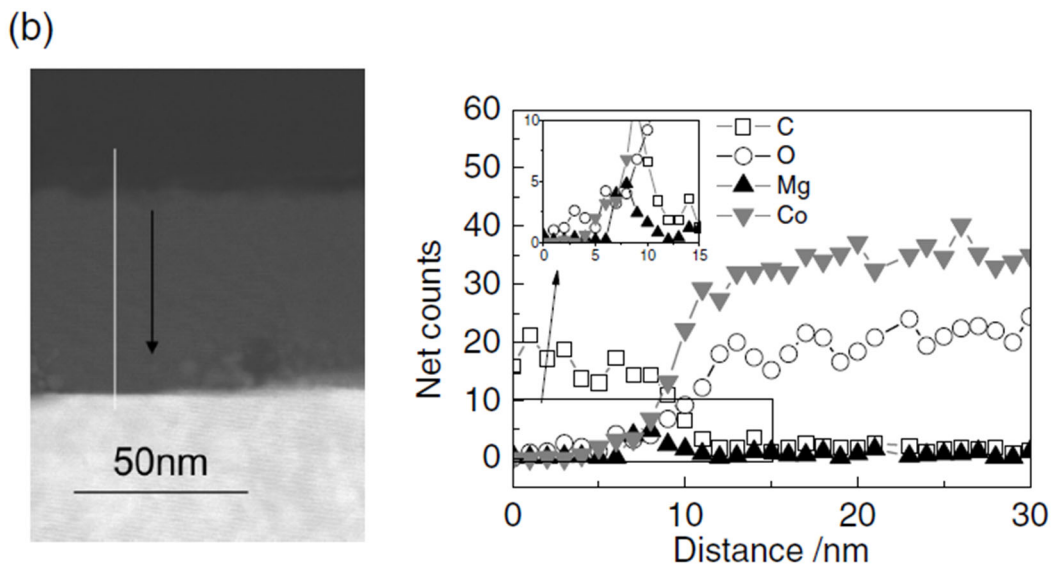
- f. *[Element 6.5]: wherein the positive electrode active material particle comprises titanium, magnesium, fluorine, and oxygen in the second region,*

Blangero discloses this limitation. *See supra*, § X.A.2.g.

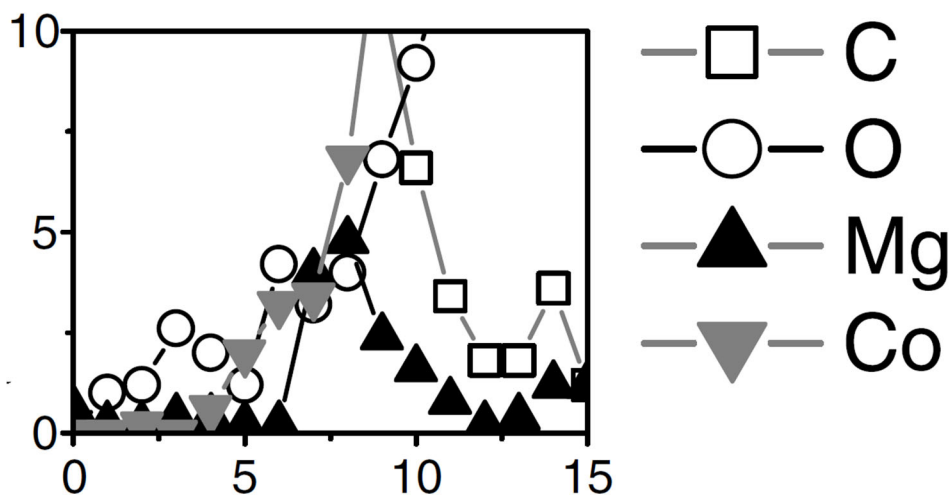
- g. *[Element 6.6]: wherein the second region extends from a surface of the positive electrode active material particle to an inside of the positive electrode active material particle where magnesium detected by a line analysis of energy dispersive X-ray spectroscopy (EDX) in a depth direction is $\frac{1}{5}$ of a maximum peak of the magnesium in the line analysis, and*

Blangero renders this limitation obvious either alone or in combination with Shim and/or Yamamoto. In Blangero's particle, one end of the second region is the surface of the particle. *See supra*, §§ X.A.2.d, X.A.2.f, X.A.2.g. A POSITA would have found it obvious that the second region extends from the PEAM's surface to a point where the amount of magnesium (as measured by EDX) is $\frac{1}{5}$ of the maximum peak of magnesium in the line analysis. Indeed, Blangero teaches that the concentration of magnesium at the surface "is at least 5 times" its concentration in the bulk. *Id.*, ¶ [0011]; Ex. 1003, ¶ 192.

Moreover, Yamamoto assessed MgO coatings on LiCoO₂ particles and conducted EDX line scans to characterize magnesium concentration through the coating region. Ex. 1007. These line scans are shown below:



Ex. 1007, Fig. 1(b). As shown in the inset below, no magnesium is detected for the first ~6 nm:



Id. Thereafter, magnesium peaks at ~5 net counts (at ~8 nm) and decreases as depth increases. Ex. 1007, Fig. 1(b). At ~12 nm, the magnesium concentration is ~1 net count, which is 1/5 of magnesium's peak. *Id.* Yamamoto confirms that, for room temperature MgO-coated LCO shown in Figure 1(b) had, "a Mg containing layer of

approximately 5 nm in thickness outside [the] Co containing layer” (*id.*, 2), corresponding to the magnesium spike and drop-off observed from the 6–12 nm range in Figure 1(b). Thus, a POSITA would have found it obvious that the magnesium concentration in a magnesium-containing coating for LiCoO₂ would reach 1/5 of its peak at the bottom edge of the layer. *See* Ex. 1003, ¶¶ 192–98.

Thus, Blangero together with a POSITA’s knowledge of Yamamoto renders the claimed range obvious. Alternatively, a POSITA would have been motivated to combine Blangero and Yamamoto for all the reasons explained in Section X.B.1. Additionally, as explained in Section X.A.6.b, a POSITA would have known that the concentration of magnesium in a PEAM particle is a result-effective variable whose optimization could have been discovered by routine experimentation. *See Applied Materials*, 692 F.3d at 1295. Ex. 1003, ¶¶ 192–98.

- h. *[Element 6.7]: wherein a crystal orientation of at least a part of the first region and a crystal orientation of at least a part of the second region are substantially aligned with each other.*

Like claim 1, the second region of claim 6 refers to a coating comprising titanium, magnesium, fluorine, and oxygen. *See* Ex. 1001, cl. 6, 11:5–13:57. Thus, Blangero and Shim render this limitation obvious for the reasons stated above in Section X.A.2.h.

3. Dependent Claim 7

- a. *[Element 7.0]: The lithium-ion secondary battery according to claim 6,*

Blangero, either alone or in combination with Shim and/or Yamamoto, renders claim 6 obvious. *See supra*, § X.B.2.

- b. *[Element 7.1]: wherein the titanium, the magnesium, the fluorine, and the oxygen are provided in a range from the surface of the positive electrode active material particle to a depth of 5 nm.*

Blangero discloses this limitation. *See supra*, § X.A.3.b.

4. Dependent Claim 8

- a. *[Element 8.0]: The lithium-ion secondary battery according to claim 6,*

Blangero, either alone or in combination with Shim and/or Yamamoto, renders claim 6 obvious. *See supra*, § X.B.2.

- b. *[Element 8.1]: wherein the positive electrode further comprises a conductive additive, and*

Blangero and Shim render this limitation obvious. *See supra*, § X.A.4.b.

- c. *[Element 8.2]: wherein the conductive additive comprises carbon fiber, graphene or multilayer graphene.*

Blangero and Shim render this limitation obvious. *See supra*, § X.A.4.c.

5. Dependent Claim 9

- a. *[Element 9.0]: The lithium-ion secondary battery according to claim 6,*

Blangero, either alone or in combination with Shim and/or Yamamoto, renders claim 6 obvious. *See supra*, § X.B.2.

- b. *[Element 9.1]: wherein a relative value of a concentration of the titanium is greater than or equal to 0.05 and less than or equal to 0.4 when the surface of the positive electrode active material particle is subjected to an XPS analysis and a concentration of cobalt is defined as 1.*

Blangero discloses this limitation. *See supra*, § X.A.5.b.

6. Dependent Claim 10

- a. *[Element 10.0]: The lithium-ion secondary battery according to claim 6,*

Blangero, either alone or in combination with Shim and/or Yamamoto, renders claim 6 obvious. *See supra*, § X.B.2.

- b. *[Element 10.1]: wherein a relative value of a concentration of the magnesium is greater than or equal to 0.4 and less than or equal to 1.5 when the surface of the positive electrode active material particle is subjected to an XPS analysis and a concentration of cobalt is defined as 1.*

Blangero renders this limitation obvious. *See supra*, § X.A.6.b.

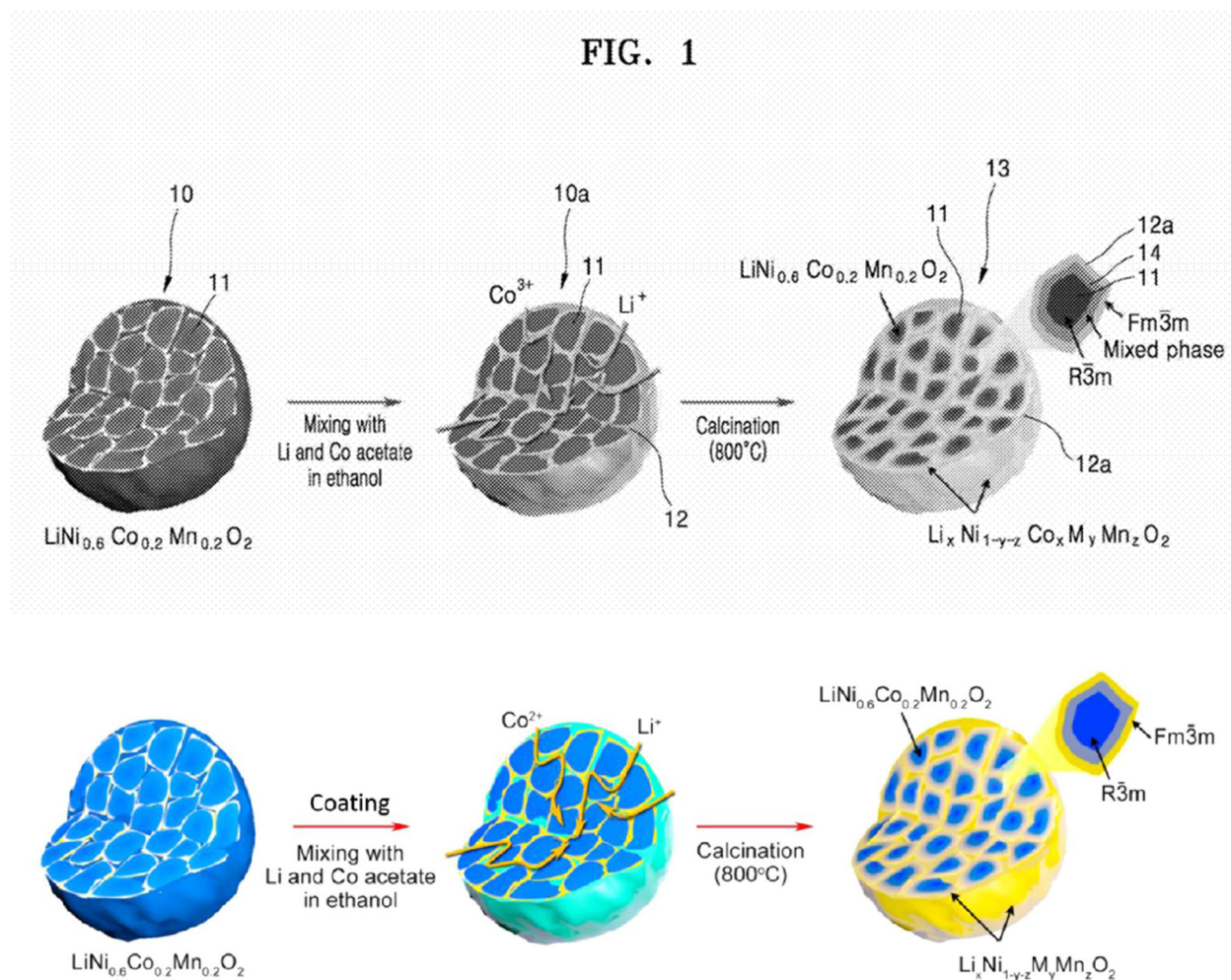
C. Ground II.A: Claims 1–3 Are Rendered Obvious by Cho Alone or in Combination with Kim

1. Motivation to Combine Cho with Kim

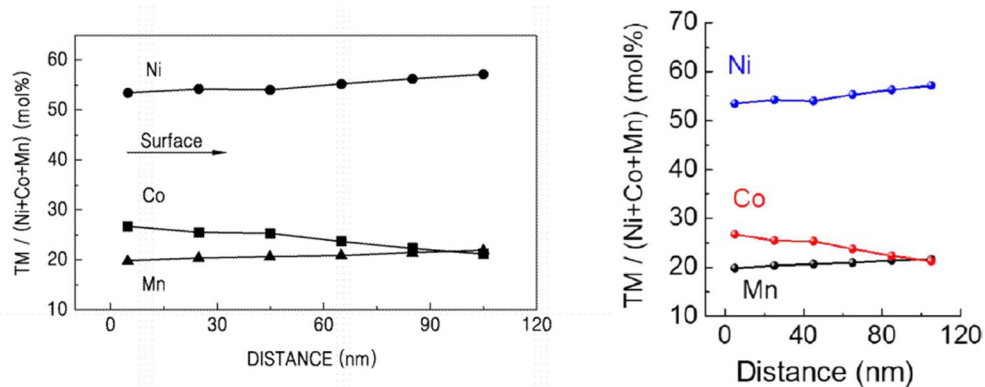
A POSITA would have been motivated to combine Cho and Kim, which would have involved routine implementation with no technical risks given their complementary teachings—improving lithium-ion battery cyclability through cathode active material coatings. A POSITA would have understood that Cho and Kim merely describe different aspects of the same research findings such that a POSITA would have read and understood their teachings together. Ex. 1003, ¶¶ 209–12.

First, Kim and Cho were authored and filed by the same researchers around the same time: February 10, 2015 and December 17, 2015, respectively. *See* Ex. 1008; Ex. 1009. There is substantial overlap between Kim’s authors and Cho’s inventors, including Jaephil Cho and Hyejung Kim, and the Ulsan National Institute of Science and Technology is credited by Kim and is one named applicant of Cho. *See id.* Thus, a POSITA would have understood that these two references were fruits of the same research group. Ex. 1003, ¶ 210. A POSITA would have understood that Kim and Cho are two references borne from the same research—using PEAM coatings to achieve “improved structural and thermal stability under severe conditions such as high cutoff voltage (>4.4 V) and high temperature (>50 °C).” Ex. 1009, 2; Ex. 1008, 4:31–57, 6:3–7.

Second, consistent with these overlapping researchers and groups, these two references exist within the same field of endeavor, discuss the same technical features (*e.g.*, lithium-ion batteries, PEAMs, coatings, crystalline structures, and battery performance), and are related references meant to be understood in concert. In fact, both references show the same figures and describe the same invention and experimental method for applying and testing lithium-ion batteries, PEAMs, and coatings, as shown below:

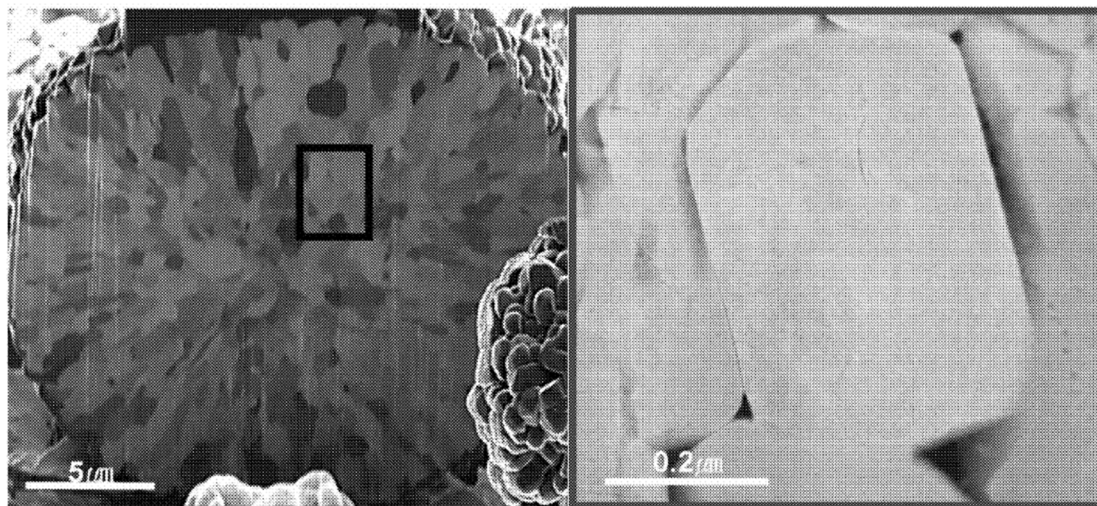


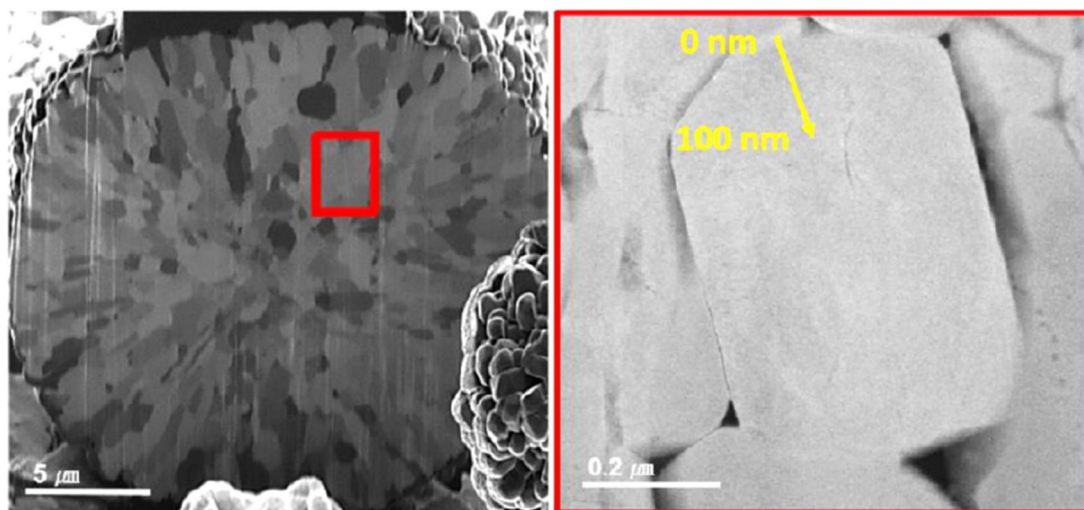
Ex. 1008, Fig. 1 (top); Ex. 1009, Fig. 1(a) (bottom) (annotations in original).



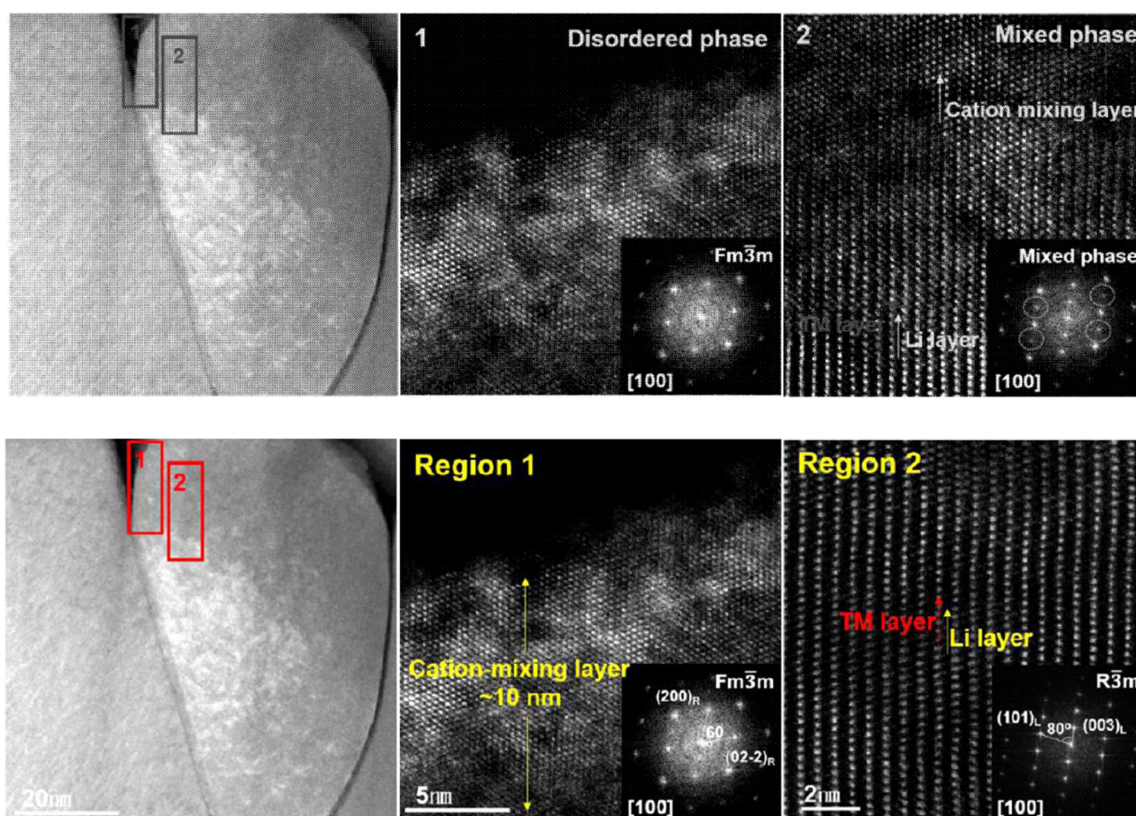
Ex. 1008, Fig. 5B (left); Ex. 1009, Fig. 1(d) (right).

Third, Kim provides additional implementation details regarding the scale, crystal structures, layers, and other aspects of Cho's particles, as shown below:

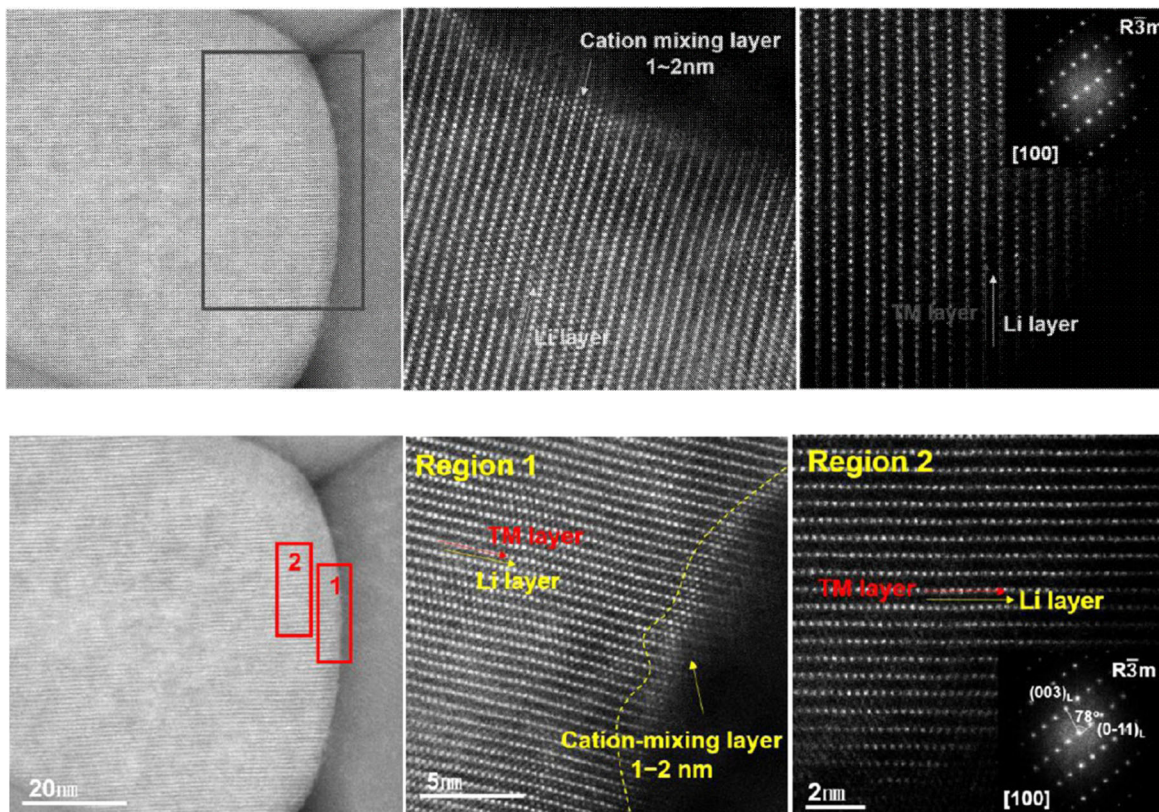




Ex. 1008, Figs. 4A–B (top); Ex. 1009, Fig. 1(b)–(c) (bottom) (annotations in original).



Ex. 1008, Figs. 7A–C (top); Ex. 1009, Figs. 1(d)–(e) (bottom).



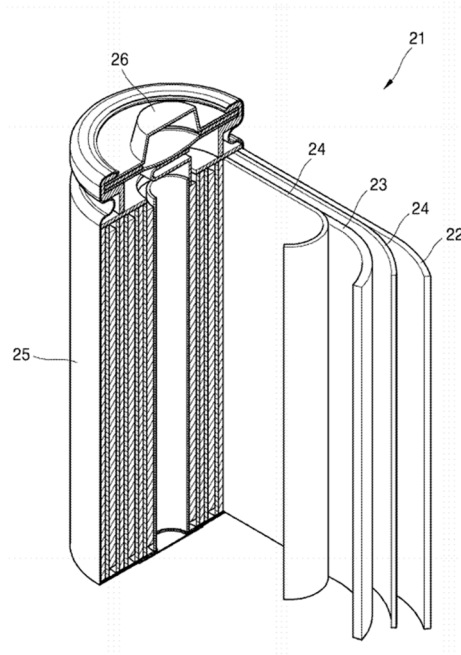
Ex. 1008, Figs. 8A–C (top); Ex. 1009, Figs. 1(a)–(c) (bottom) (showing similar, rotated images) (annotations in original); Ex. 1003, ¶¶ 211. Thus, as shown in the Kim’s yellow and red annotations above, a POSITA would have naturally looked to Kim to illustrate the boundaries and crystal structures of Cho’s particles. Ex. 1003, ¶¶ 209–12.

2. Independent Claim 1

a. *[Preamble]: A lithium-ion secondary battery comprising:*

To the extent the preamble is limiting, Cho discloses it. Cho is directed to “[a] composite cathode active material” for a “lithium ion battery.” Ex. 1008, Abstract,

12:62–63. Figure 2, reproduced below, shows a “schematic perspective view of a lithium battery” which can be a lithium-ion battery:



Id., Fig. 2, 2:31–32, 12:61–63; Ex. 1003, ¶ 213.

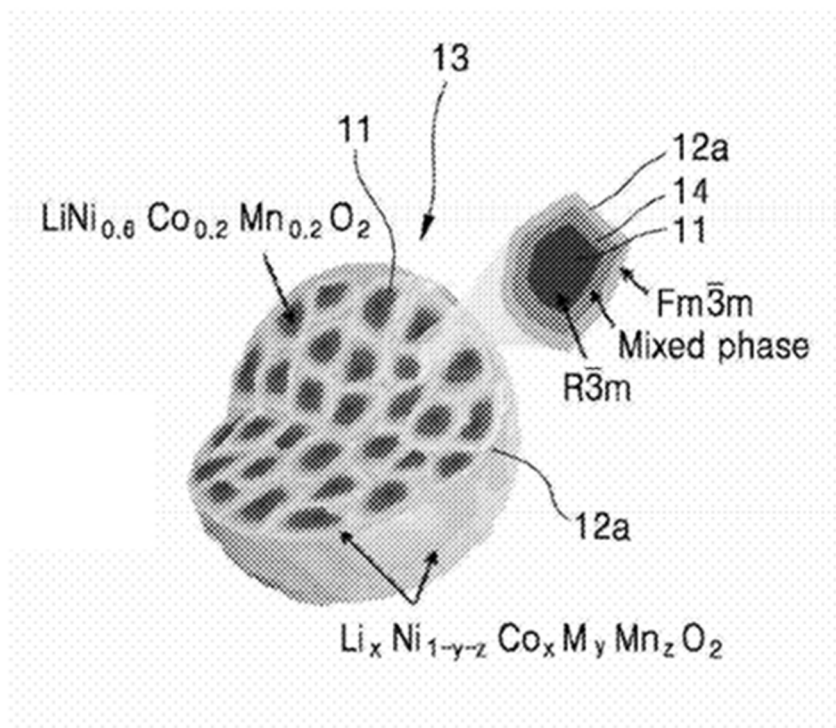
- b. *[Element 1.1]: a positive electrode, the positive electrode comprising a positive electrode active material particle comprising lithium cobaltate,*

Cho discloses this limitation. **First**, Cho explicitly refers to lithium cobaltate as the cathode active material. Ex. 1008, 9:21–22 (“Examples of the cathode active material used in the art may include one or more of a ***lithium cobalt oxide***.”), 10:8–9 (“[T]he cathode active material may be . . . ***LiCoO₂***[.]”); Ex. 1003, ¶ 215. Although some of Cho’s examples describe a PEAM made from lithium nickel cobalt manganese oxide (NCM), Cho makes clear that “[a]ny cathode active material used in the art may be further used.” Ex. 1008, 9:25–26.

Second, Cho confirms that its teachings go beyond NCM-based PEAMs, as “the cathode active material may be a compound that is represented by one of [several] formulae,” which expressly include LiCoO_2 . *See id.* 9:27–58. Cho’s first PEAM formula is $\text{Li}_a\text{A}_{1-b}\text{B}_b\text{D}_2$, where either A and B can be cobalt, D can be oxygen, a can be 1, and b can be 0. *See id.* With these parameters, Cho’s first PEAM formula is LiCoO_2 . *See id.*; Ex. 1003, ¶¶ 214–15.

- c. *[Element 1.2]: wherein the positive electrode active material particle comprises a first region and a second region,*

Cho discloses this limitation. Cho teaches “a coating layer on a surface”—namely, that “coating layer 12a may have a distinct boundary with the primary particle 11”:

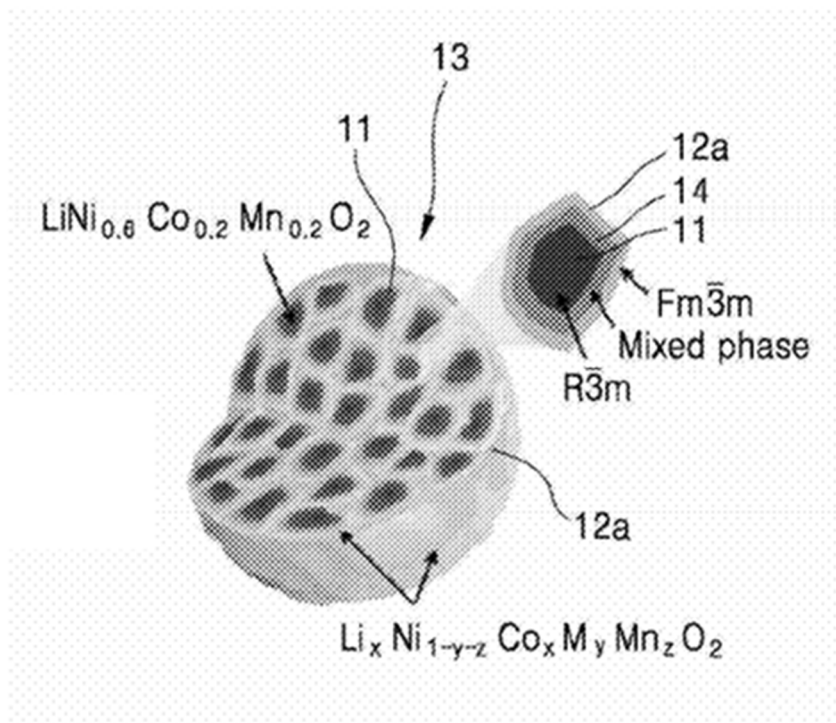


Ex. 1008, Fig. 1 (excerpted), 7:15–18, 9:59–60; *see also id.*, 1:35–40, 2:21–25, 7:61–64, 14:57–61, 15:8–52, Figs. 7, 8. As shown above, Cho teaches a first region with space group R-3m and second region 12a with space group Fm-3m. *See id.*, Fig. 1.¹ Moreover, Cho teaches a “mixed phase” formed between the two regions. *See id.*, 7:12–14. Ex. 1003, ¶ 216.

- d. *[Element 1.3]: wherein the first region comprises a layered rock-salt crystal structure,*

Cho discloses this limitation. The '660 Patent defines “layered rock-salt crystal structure” as having a “space group of . . . R-3m,” as opposed to “space group Fm-3m of a general rock-salt crystal.” Ex. 1001. Cho’s first region has “a layered structure (a space structure of R-3m),” as shown below:

¹ Although Figure 1 is specifically drawn showing an NCM-based PEAM, Cho’s teachings equally apply to LiCoO₂ PEAMs. *See supra*, § X.C.2.b.

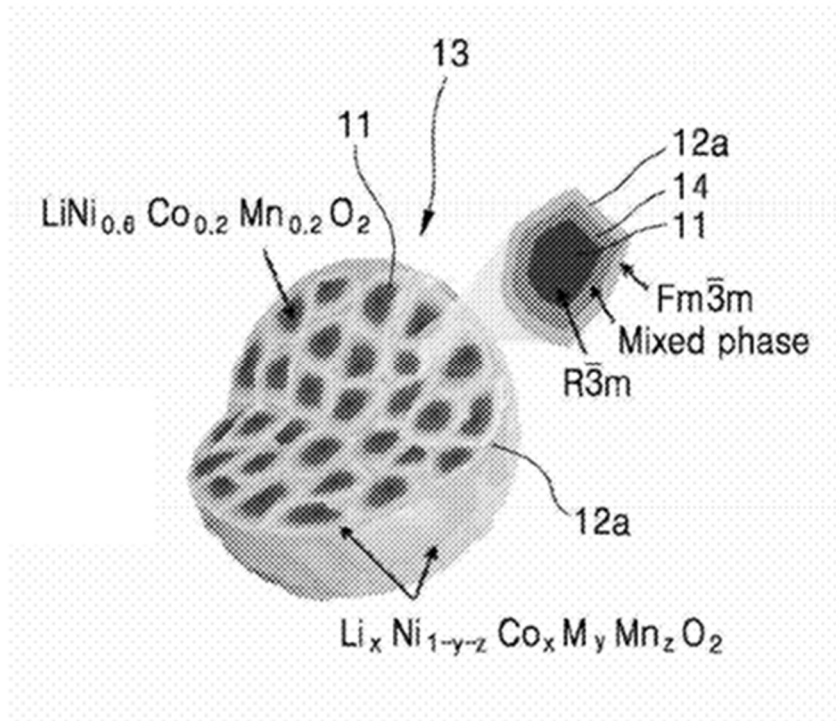


Ex. 1008, Fig. 1 (excerpted), 10:8–9. A POSITA would have known that an LiCoO_2 PEAM would have a “[l]ayered rock-salt structure” (R-3m). *See supra*, § X.A.2.d; Ex. 1025, 1; Ex. 1026, 4–5; Ex. 1003, ¶¶ 217–19.

- e. *[Element 1.4]: wherein the second region comprises a rock-salt crystal structure,*

Cho discloses this limitation. **First**, the ’660 Patent describes a “general rock-salt crystal” structure as having “a space group Fm-3m,” unlike “layered rock-salt,” which has space group “R-3m.” Ex. 1001, 8:67–9:3. Cho’s second region has

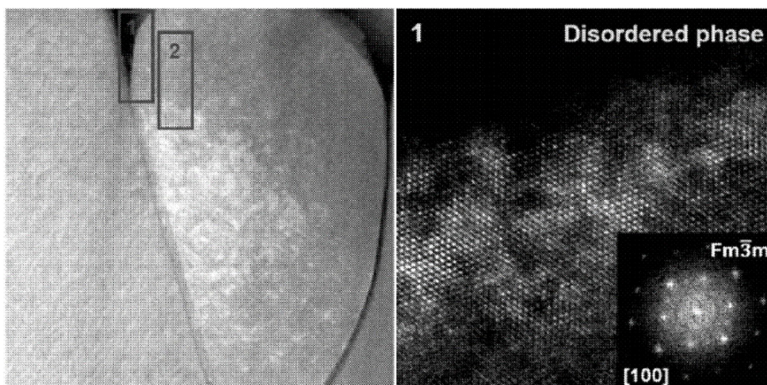
“coating layer 12a” with “rock-salt layer structure (a space group of Fm-3m)” as shown below:²



Id., Fig. 1 (excerpted), 7:7–14. Ex. 1003, ¶ 221.

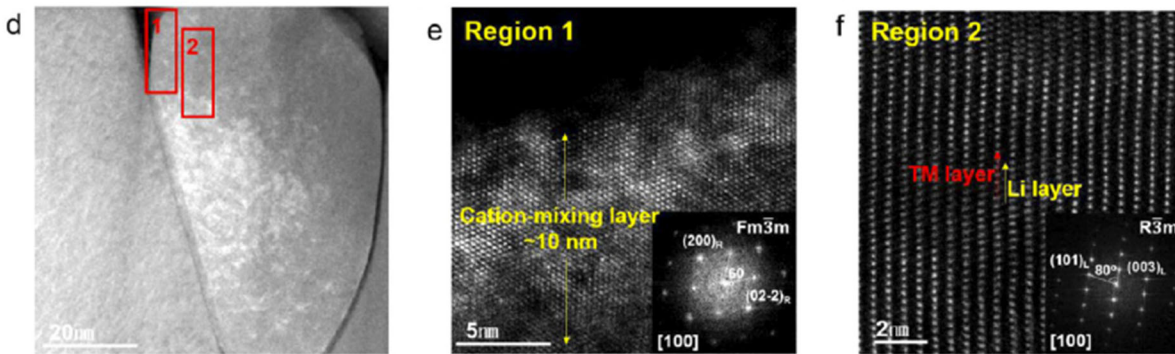
² Cho uses “rock-salt layer structure” to refer to the rock salt structure of the coating layer and “layered structure” to refer to the layered rock salt structure of the first region. Ex. 1008, 7:7–14. Although this terminology varies slightly from that of the ’660 Patent, Cho confirms that first region 11’s structure has space group R-3m while coating 12a’s structure has space group Fm-3m—consistent with the ’660 Patent’s descriptions. *See id.*; Ex. 1001, 8:67–9:3, cl. 1; Ex. 1003, ¶ 224.

Second, Cho confirms its coatings have rock-salt structure. As shown below, Figure 7A (left) shows Cho's particle where region 1 (left box) is at the "exterior" of the particle (*i.e.*, a portion containing the coating). Ex. 1008, 17:44–48. Figure 7B (right) shows a STEM image within region 1 illustrating the crystal structure (space group Fm-3m):



Id., Figs. 7A (left), 7B (right); *see also id.*, 17:58–61 (describing “an exterior of the primary particle at region 1 . . . having **a rock-salt structure**”).

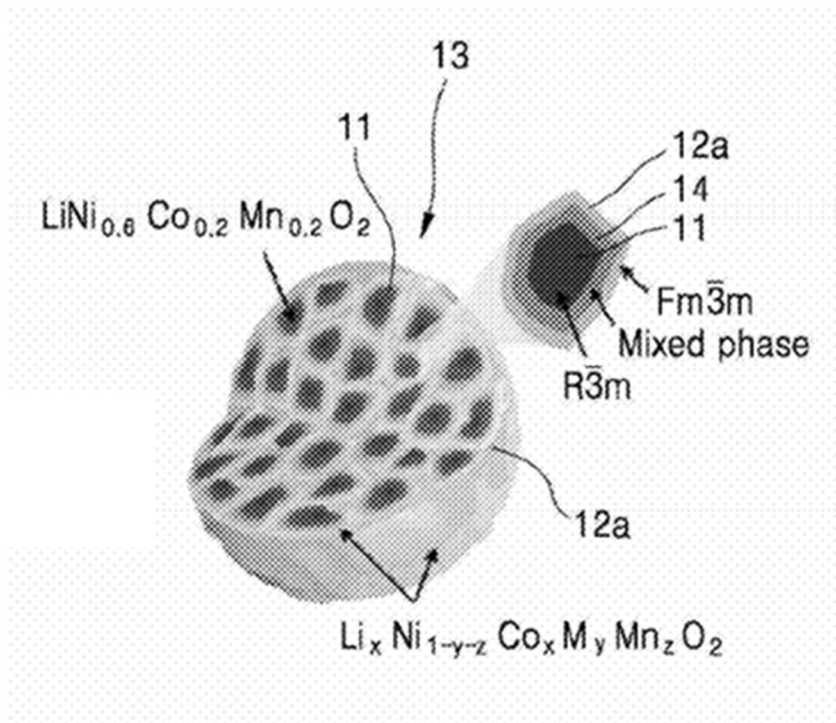
Cho teaches a “cation-mixing layer” that is also part of the second region, since it comprises the coating and “ha[s] a rock-salt phase.” *Id.*, 5:48–52. With respect to Figure 7B (above, right), Cho teaches that “[a] **surface phase** of the primary particle was a cation-mixing layer having a rock-salt phase.” Analogous images from Kim (below) confirm that this cation-mixing layer (comprising the coating in region 1, near the surface of the particle) has rock-salt structure (space group Fm-3m), while the lithium within the active material (in region 2, away from the surface of the particle) has layered rock-salt structure (space group R-3m):



Ex. 1009, Fig. 2(d)–(f). A POSITA would have understood that Kim’s teachings apply to Cho. *See supra*, § X.C.1; Ex. 1003, ¶¶ 220–24.

f. [Element 1.5]: wherein the second region covers at least a first part of the first region,

Cho discloses this limitation. Cho teaches a particle with a PEAM (first region) that may be LiCoO_2 and a coating layer covering the first region:



Ex. 1008, Fig. 1 (excerpted). As shown above, second region 12a covers at least a part of first region 11. *See id.*, 4:41–42, 5:54–55, 7:7–12; Ex. 1003, ¶ 225.

- g. *[Element 1.6]: wherein the positive electrode active material particle comprises titanium, magnesium, fluorine, and oxygen in the second region, and*

Cho discloses this limitation. **First**, Cho teaches that its “coating layer may include a coating element compound, such as an *oxide* of a coating element,” including Mg and Ti, “or a mixture thereof.” Ex. 1008, 9:59–10:2; Ex. 1003, ¶ 226.

Second, Cho further teaches that the second region comprises fluorine, especially in view of a LiPF₆ electrolyte. Cho’s electrolyte contains “a lithium salt” which can “include LiPF₆.” Ex. 1008, 12:13–30, 16:4–9 (LiPF₆ used in enumerated examples). Additionally, Cho explains that “[t]he coating layer may include [] a product obtained by a sol-gel reaction of compositions including a *lithium salt*[.]” *Id.*, 5:29–31. A POSITA would have understood that such reactions of LiPF₆ would lead to the formation of a fluorine-coating layer on the cathode surface. *See supra*, § VII.C.

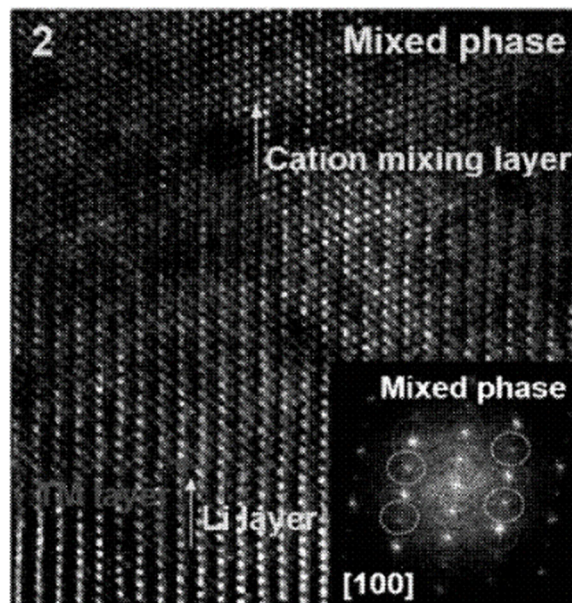
Kim further explains that “a new solid electrolyte interface (SEI) layer, comprising *decomposition products of the electrolyte*, is formed along the active surface of the primary particles (grains) developed by the microcracks” of the cathode material. Ex. 1009, 2–3. Thus, when LiPF₆ is used in the electrolyte (as both

Kim and Cho teach), Kim teaches that fluorine-containing layer is formed on the particle. Ex. 1003, ¶¶ 226–28.

- h. *[Element 1.7]: wherein a crystal orientation of at least a second part of the first region and a crystal orientation of at least a part of the second region are substantially aligned with each other.*

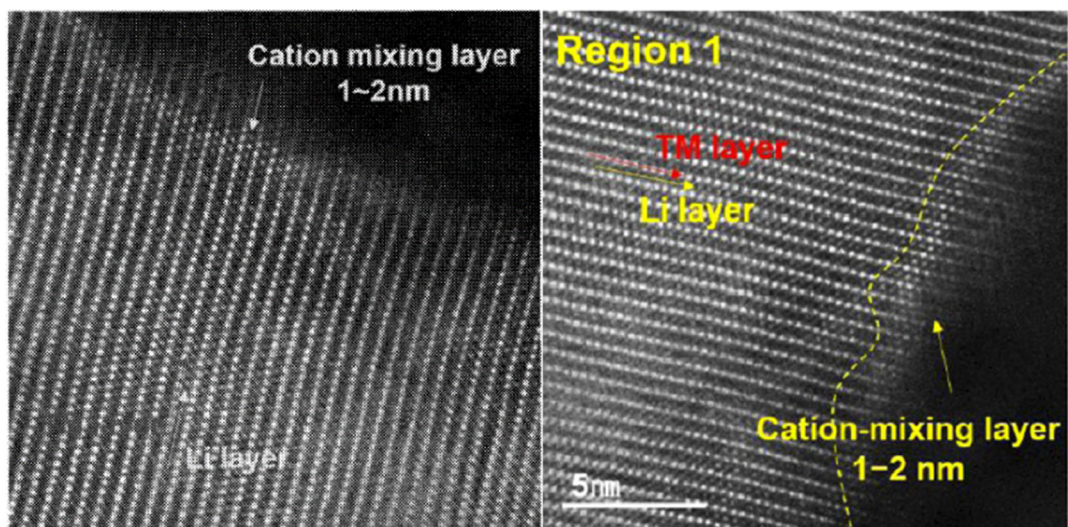
Cho discloses this limitation. The '660 Patent explains that “crystal orientations” are “substantially aligned with each other” when the angle between crystal planes “is less than or equal to 5°[.]” Ex. 1001, 9:22–29.

Cho’s Figure 7C demonstrates substantial alignment between the rock-salt crystal of the second region (cation mixing layer) and the layered rock-salt crystal of the first region:



Ex. 1008, Fig. 7B. As shown above, the bright and dark lines in both regions are both oriented vertically—the angle between planes is $\sim 0^\circ$, indicating substantial alignment. Ex. 1003, ¶ 229–30.

Cho's Figure 8B and Kim's Figure 2B (which shows an annotated and rotated version of the same image), further illustrate substantial alignment:



Ex. 1008, Fig. 7B (left); Ex. 1009, Fig. 2(b) (right) (annotations in original). As shown above, the crystal diffraction lines in the cation-mixing layer (second region) are substantially aligned with those in the lithium-containing layer (first region)—the angles between the bright and dark lines in the cation-mixing layer and the lithium layer measure 0° , which is less than 5° , illustrating substantial alignment. Ex. 1003, ¶ 231. A POSITA would have understood that Kim's teachings apply to Cho. *See supra*, § X.C.1.

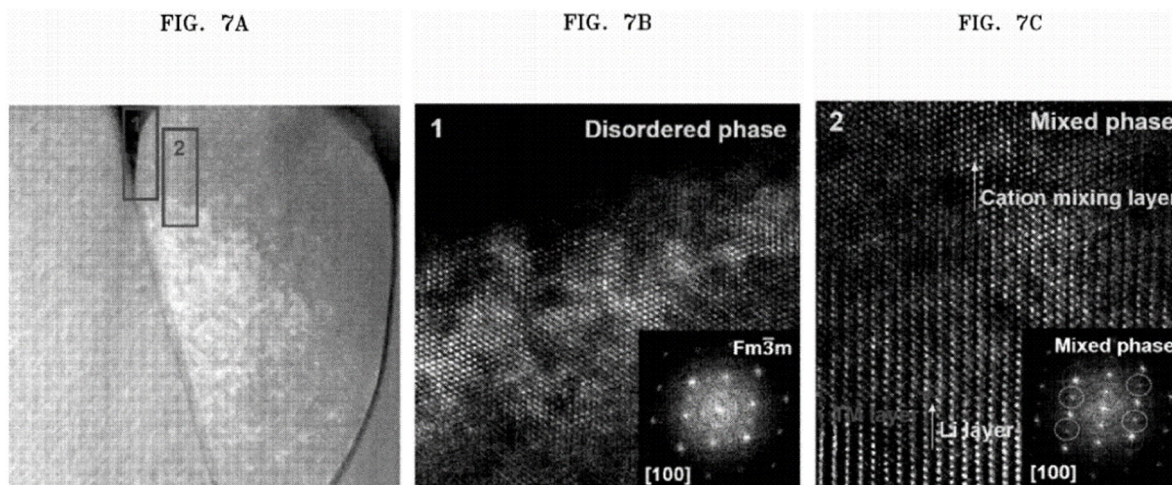
3. Dependent Claim 2

- a. *[Element 2.0]: The lithium-ion secondary battery according to claim 1,*

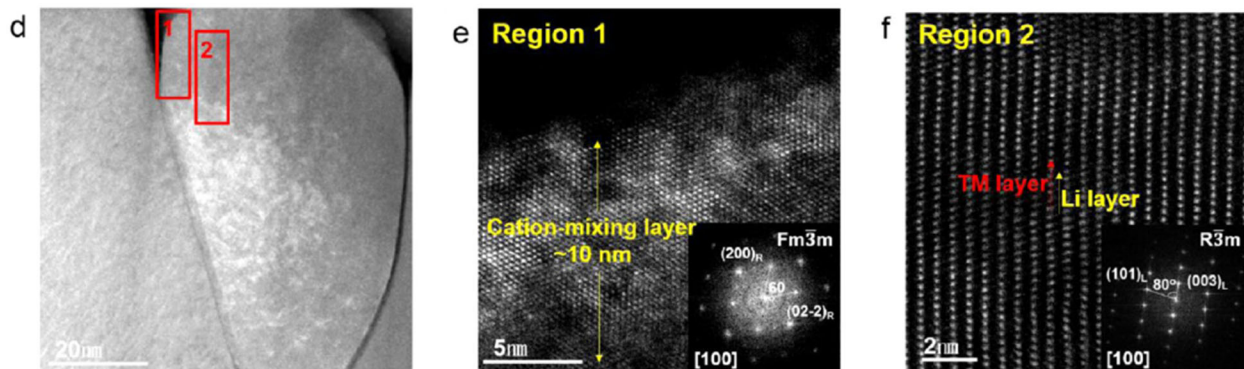
Cho, alone or with Kim, renders claim 1 obvious. *See supra*, § X.C.2.

- b. *[Element 2.1]: wherein the titanium, the magnesium, the fluorine, and the oxygen are provided in a range from the surface of the positive electrode active material particle to a depth of 5 nm.*

Cho renders this limitation obvious. Cho discloses a coating layer comprising titanium, magnesium, and oxygen. *See supra*, § X.C.2.g, Ex. 1008, 2:5–11, 9:59–62, 12:13–30. Cho teaches that the “thickness of the coating layer may be . . . in a range of about 1 nm to about 20 nm.” *Id.*, 5:9–11, *see also id.*, 1:49–50, 5:11–18, cl. 3. These coatings layers are shown in the below images:

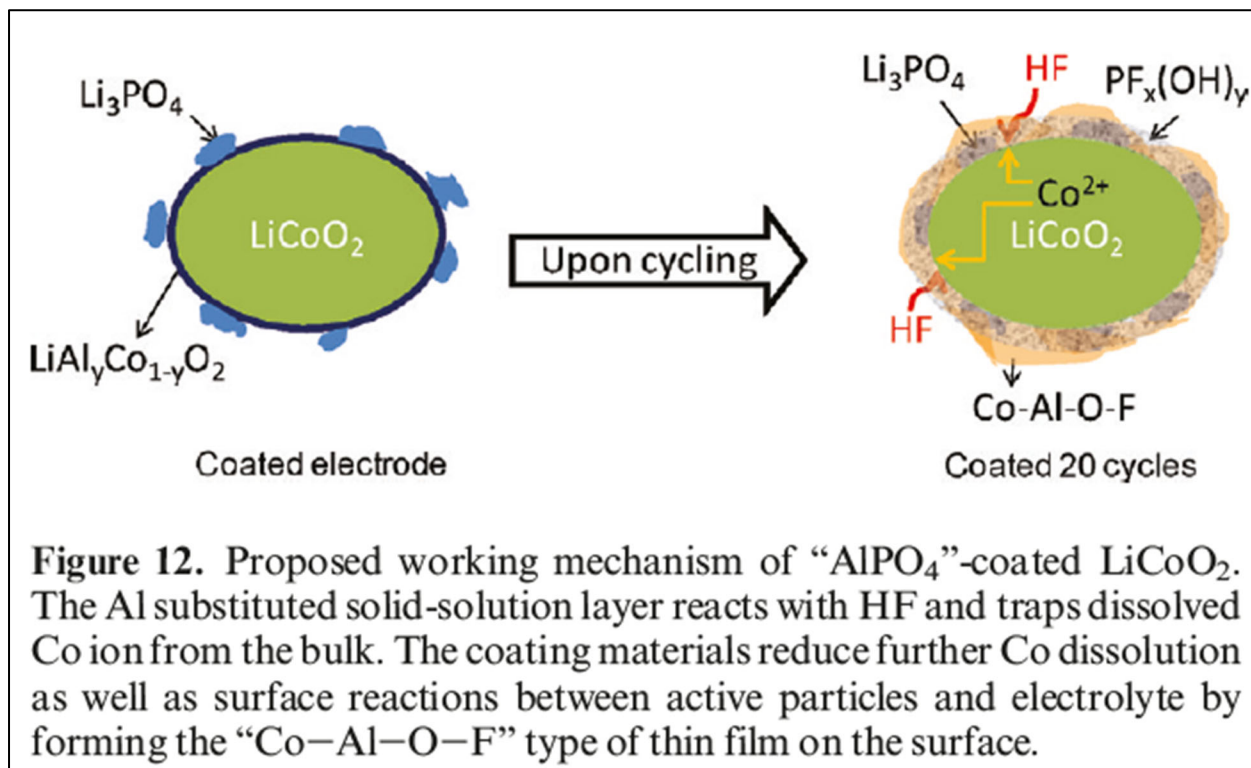


Ex. 1008, Figs. 7A (HR-TEM), 7B–7C (STEM). A POSITA would understand the Fm-3m coating layer is at least 5 nm thick from the surface of the PEAM, as Kim provides scale lengths for the same images:



Ex. 1009, Figs. 2(d)–(f). Thus, a POSITA would have understood that titanium, magnesium, and oxygen are provided in the claimed range. Ex. 1003, ¶¶ 233–34.

A POSITA would have understood Cho’s PEAM includes fluorine because Cho’s use of LiPF_6 would lead to a “very thin surface layer that predominat[ely] consists of LiF and $\text{Li}_x\text{PF}_y\text{O}_z$ ” on the PEAM’s surface. *See supra*, §§ VII.C, X.C.2.g; Ex. 1026, 16. This surface layer incorporates fluorine and material from the coating layer:



Id., Fig. 12. Similarly, a POSITA would have understood that fluorine would interact with Cho’s titanium-, magnesium-, and oxygen-containing coating in the same way to form a surface coating comprising all four elements. Ex. 1003, ¶¶ 233–36.

4. Dependent Claim 3

- a. *[Element 3.0]: The lithium-ion secondary battery according to claim 1,*

Cho, alone or with Kim, renders claim 1 obvious. *See supra*, § X.C.2.

- b. *[Element 3.1]: wherein the positive electrode further comprises a conductive additive, and*

Cho discloses this element. Cho discloses “a cathode active material composition may be prepared by mixing the composite cathode active material, *a conducting agent*, a binder, and a solvent.” Ex. 1008, 9:7–9.

- c. *[Element 3.2]: wherein the conductive additive comprises carbon fiber, graphene or multilayer graphene.*

Cho discloses this element. Cho explains that “[a]ny conducting agent used in the art may be used.” Ex. 1008, 10:13–14. Moreover, “[e]xamples of the conducting agent may include carbon black or *graphite particles*,” and further examples include “conductive fibers such as *carbon fibers*.” *Id.*, 10:12–20. Moreover, a POSITA would have found using “graphene” and “multilayer graphene” obvious from Cho, as “graphite” (whether natural or artificial) is a carbon structure composed of multiple layers of graphene. Ex. 1003, ¶ 239.

D. Ground II.B: Claims 4 And 5 Are Rendered Obvious by Cho Alone or in Combination with Kim and/or Blangero

1. Motivation to Combine Cho with Blangero

A POSITA would have had several reasons to combine Blangero’s titanium doping with Cho’s particle. Given their complementary teachings, this combination would have involved routine implementation with no technical risks. Ex. 1003, ¶¶ 240–42.

First, a POSITA would have recognized that Cho and Blangero are directed to improving PEAMs for enhanced battery performance. Both references teach lithium-ion batteries with the same cathode particle (LiCoO_2) treated with the same metals, titanium and magnesium, in a surface layer. Ex. 1008, 10:8–9, 1:64–2:11, 5:11–14 (describing “excellent capacity and lifespan characteristics” of Cho’s coating), 7:23–31, 9:67–10:2; Ex. 1005, ¶¶ [0004], [0005], [0094], [0108]–[0110]

(describing particles based on LiCoO_2 doped and coated with Mg and Ti). Ex. 1003, ¶ 240.

Second, both references address the same problem—using doping and coating techniques. *See* Ex. 1008, 3:63–65 (“[L]ithium transition metal oxide may have excellent capacity characteristics and high energy capacity[.]”); 7:23–40, 9:59–10:7, 19:3–32; Ex. 1005, ¶¶ [0004], [0005]–[0007]. A POSITA would have had a reasonable expectation of success in making this combination—it was well-known in the art that magnesium and titanium could be used in a coating or added to the bulk of the PEAM via doping. Ex. 1008, 1:64–2:11, 7:23–31; Ex. 1003, ¶ 241. For the same reasons, this combination represents using a “known technique to improve similar devices [and methods] in the same way,” applying “a known technique” to “a known device ready for improvement” to yield predictable results, and combining known prior-art elements “according to known methods to yield predictable results.” *KSR*, 550 U.S. at 417.

Third, Blangero provides express motivations to use its doping and coating techniques with Cho’s particle. Blangero’s dopants (Ti and Mg) lead to an “in-situ” coating of a surface layer “enriched in oxidized compounds, like MgO and TiO_2 , that may also be lithiated.” Ex. 1005, ¶¶ [0090], [0094]. This “inert coating layer provides additional safety when the powders are in contact with the electrolyte of the battery.” *Id.*, ¶¶ [0093]–[0094]; Ex. 1003, ¶ 242.

2. Dependent Claim 4

- a. *[Element 4.0]: The lithium-ion secondary battery according to claim 1,*

Cho, alone or with Kim, renders claim 1 obvious. *See supra*, § X.C.2.

- b. *[Element 4.1]: wherein a relative value of a concentration of the titanium is greater than or equal to 0.05 and less than or equal to 0.4 when the surface of the positive electrode active material particle is subjected to an XPS analysis and a concentration of cobalt is defined as 1.*

A POSITA would have understood from Blangero that Cho renders obvious the claimed Ti:Co concentration ratio range. As explained in Section X.A.5.b, Blangero teaches a Ti:Co ratio of approximately 0.0917:

TABLE 3		
elemental composition of the surface of the grains of LCO-1 and Ex1.		
at. %	LCO-1	Ex1
Li	21.7	15.3
Co	8.7	12.0
O	41.9	37.5
C	23.1	26.5
S	1.3	0.8
Ca	0.6	0.1
F	0.9	0.4
Ti	0.9	1.1
Na	0.3	0.3
Si	Below detection limit	1.1
P	0.4	0.6
Mg	Below detection limit	4.4

Id., [0129] (Table 3) (annotated); *see also id.* Fig. 4 (showing XPS spectra for Example 1); *see also* Ex. 1011, 3, Table 3 (showing similar Ti:Co ratio of 0.0849 at the surface of a doped LiCoO₂ particle); Ex. 1003, ¶ 244.

Thus, Cho and a POSITA's knowledge of Blangero renders the claimed range obvious. Alternatively, a POSITA would have been motivated to combine Cho and Blangero for the reasons explained in Section X.D.1. Moreover, a POSITA would have understood that the optimum range of Ti:Co concentration ratios could have been discovered by routine experimentation, thus rendering the claimed range obvious over Cho and Blangero. *See Applied Materials*, 692 F.3d at 1295; Ex. 1003, ¶¶ 244–46.

3. Dependent Claim 5

- a. *[Element 5.0]: The lithium-ion secondary battery according to claim 1,*

Cho, alone or with Kim, renders claim 1 obvious. *See supra*, § X.C.2.

- b. *[Element 5.1]: wherein a relative value of a concentration of the magnesium is greater than or equal to 0.4 and less than or equal to 1.5 when the surface of the positive electrode active material particle is subjected to an XPS analysis and a concentration of cobalt is defined as 1.*

A POSITA would have understood from Blangero that Cho's particle renders obvious the claimed Mg:Co concentration ratio range. As explained in Section X.A.6.b, Blangero measures this ratio as ~0.367 at the particle's surface:

TABLE 3

elemental composition of the surface of the grains of LCO-1 and Ex1.		
at. %	LCO-1	Ex1
Li	21.7	15.3
Co	8.7	12.0
O	41.9	37.5
C	23.1	26.5
S	1.3	0.8
Ca	0.6	0.1
F	0.9	0.4
Ti	0.9	1.1
Na	0.3	0.3
Si	Below detection limit	1.1
P	0.4	0.6
Mg	Below detection limit	4.4

Id., [0129] (Table 3) (annotated); Ex. 1003, ¶ 248.

A POSITA would have understood that this Mg:Co ratio renders the claimed range obvious. Specifically, a POSITA would have understood that Mg:Co concentration is a result-effective variable whose optimum range could have been discovered by routine experimentation. *See supra*, § X.A.6.b. “[I]t is not inventive to discover the optimum or workable ranges by routine experimentation, if the parameter is known to be a result-effective variable.” *Applied Materials*, 692 F.3d at 1295; *see also Aller*, 220 F.2d at 459 (affirming obviousness rejection over reference that described 10% sulfuric acid concentration and 100° C process even where claims recited sulfuric acid concentration range of 25–70% and temperature range of 40–80° C). A POSITA would have further understood that the optimum range of Mg:Co concentration could be discovered by routine experimentation in

view of other studies showing concentrations in the claimed range. *See* Ex. 1012, Fig. 5(a) (showing Mg:Co ratio of 1.25 at the surface of a coated LiCoO₂ particle); Ex. 1003, ¶¶ 248–52.

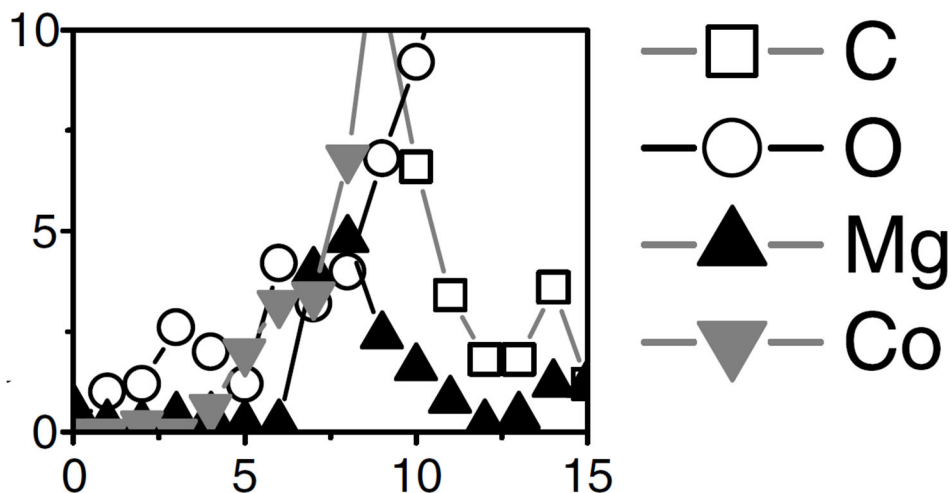
Thus, Cho and a POSITA's knowledge of Blangero render the claimed range obvious. Alternatively, a POSITA would have been motivated to combine Cho and Blangero for the reasons explained in Section X.C.1.

E. Ground II.C: Claims 6–8 Are Rendered Obvious by Cho Alone or in Combination with Kim and/or Yamamoto

1. Motivation to Combine Cho with Yamamoto

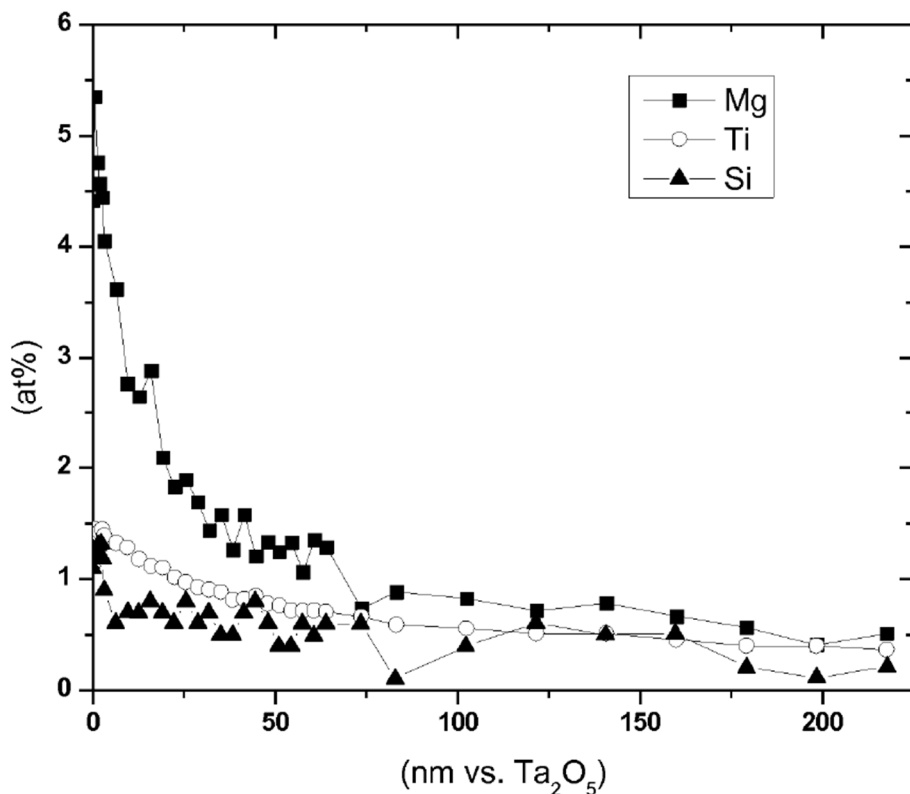
A POSITA would have been motivated to combine Yamamoto's teachings in Cho's particle. Given their complementary teachings, this combination would have involved routine implementation with no technical risks. Ex. 1003, ¶¶ 253–58.

First, as explained in Section X.B.1, Yamamoto teaches a simple concept—that a Mg-containing layer experiences a concentration peak within a surface layer and decreases in a depth direction:



Ex. 1007, 2, Fig. 1(b). At some given depth, the concentration of magnesium will be 1/5 of its maximum concentration. Ex. 1003, ¶¶ 179–80, 266.

Second, as previously explained, Blangero’s XPS depth profiling analysis corroborates Yamamoto’s teachings:



Ex. 1005, Fig. 8, ¶ [0135]; Ex. 1003, ¶ 253–58.

Third, a POSITA would have recognized that Cho and Yamamoto are both directed to improving PEAMs for enhanced battery performance. To this end, both references teach coating LiCoO₂ active materials with compounds containing magnesium and oxygen to attain this specific benefit. Ex. 1008, 9:59–10:7 (describing a coating comprising “an oxide of a coating element” such as “Mg”), 5:11–14 (describing “excellent capacity and lifespan characteristics” of Cho’s coating); Ex. 1007, 1 (“The MgO coating improves the durability of the cathode during high-potential cycling. . . . [T]he MgO coating suppresses drastic distortions of local structure at the LiCoO₂ surface.”). Ex. 1003, ¶¶ 253–58.

2. Independent Claim 6

a. *[Preamble]: A lithium-ion secondary battery comprising*

To the extent the preamble is limiting, Cho discloses it. *See supra*, § X.C.2.a.

b. *[Element 6.1]: a positive electrode, the positive electrode comprising a positive electrode active material particle comprising lithium cobaltate,*

Cho discloses this limitation. *See supra*, § X.A.2.b.

c. *[Element 6.2]: wherein the positive electrode active material particle comprises a first region and a second region,*

Cho discloses this limitation. *See supra*, § X.C.2.c.

- d. *[Element 6.3]: wherein the first region comprises a layered rock-salt crystal structure,*

Cho discloses this limitation. *See supra*, § X.C.2.d.

- e. *[Element 6.4]: wherein the second region comprises a rock-salt crystal structure,*

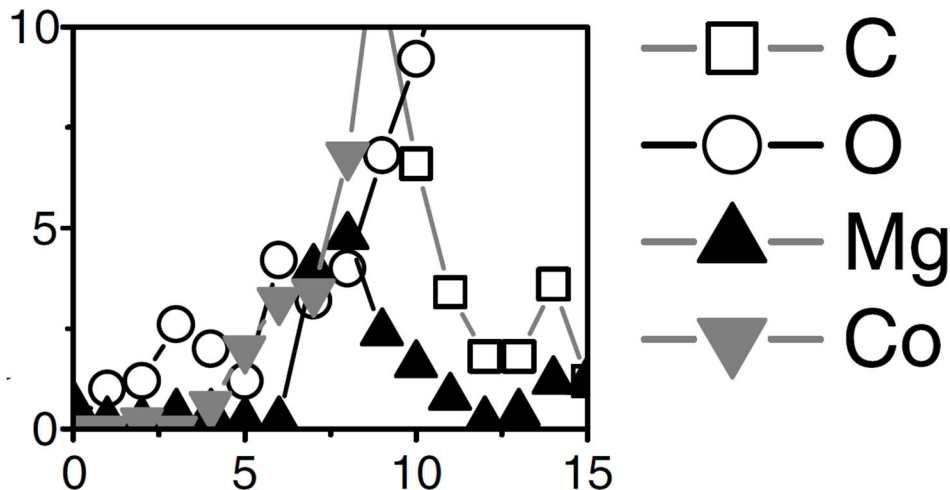
Cho, alone or with Kim, renders this limitation obvious. *See supra*, § X.C.2.e.

- f. *[Element 6.5]: wherein the positive electrode active material particle comprises titanium, magnesium, fluorine, and oxygen in the second region,*

Cho, alone or with Kim, renders this limitation obvious. *See supra*, § X.C.2.g.

- g. *[Element 6.6]: wherein the second region extends from a surface of the positive electrode active material particle to an inside of the positive electrode active material particle where magnesium detected by a line analysis of energy dispersive X-ray spectroscopy (EDX) in a depth direction is 1/5 of a maximum peak of the magnesium in the line analysis, and*

Cho renders this element obvious. In Cho's particle, one end of the second region is the surface of the particle. *See supra*, § X.C.3.b (showing that the second region is at the surface of the particle). A POSITA would have understood from Yamamoto that the second region extends to its other end—namely, where the amount of magnesium (as measured by EDX line analysis) is 1/5 of its maximum peak.



Ex. 1007, Fig. 1(b). As discussed in Section X.B.2.g, Yamamoto teaches that magnesium appears at ~7 nm, peaks shortly thereafter at 5 net counts, and reaches 1/5 of its peak concentration at ~12 nm—approximately the depth of Yamamoto’s 5 nm magnesium-containing region—which teaches the claimed concentration relationship. Ex. 1003, ¶¶ 265–68.

Thus, Cho and a POSITA’s knowledge of Yamamoto renders the claimed range obvious. Alternatively, a POSITA would have been motivated to combine Cho and Yamamoto for the reasons explained in Section X.B.1. Additionally, as explained in Section X.D.3.b, a POSITA would have known that the concentration of magnesium in a PEAM particle is a result-effective variable whose optimization could have been discovered by routine experimentation. *See Applied Materials*, 692 F.3d at 1295. Ex. 1003, ¶¶ 265–68.

- h. *[Element 6.7]: wherein a crystal orientation of at least a part of the first region and a crystal orientation of at least*

a part of the second region are substantially aligned with each other.

Like claim 1, the second region of claim 6 refers to a coating comprising titanium, magnesium, fluorine, and oxygen. *See* Ex. 1001, cl. 6, 11:5–12:16 (describing titanium, magnesium, fluorine, and oxygen in a second region over the first region), 12:17–13:57. Thus, Cho discloses this limitation for the reasons stated above in Section X.C.2.h.

3. Dependent Claim 7

- a. *[Element 7.0]: The lithium-ion secondary battery according to claim 6,*

Cho, alone or with Kim and/or Yamamoto, renders claim 6 obvious. *See supra*, § X.E.1.

- b. *[Element 7.1]: wherein the titanium, the magnesium, the fluorine, and the oxygen are provided in a range from the surface of the positive electrode active material particle to a depth of 5 nm.*

Cho discloses this limitation. *See supra*, § X.C.3.b.

4. Dependent Claim 8

- a. *[Element 8.0]: The lithium-ion secondary battery according to claim 6,*

Cho, alone or with Kim and/or Yamamoto, renders claim 6 obvious. *See supra*, § X.E.1.

- b. *[Element 8.1]: wherein the positive electrode further comprises a conductive additive, and*

Cho discloses this limitation. *See supra*, § X.C.4.b.

- c. *[Element 8.2]: wherein the conductive additive comprises carbon fiber, graphene or multilayer graphene.*

Cho discloses this limitation. *See supra*, § X.C.4.c.

F. Ground II.D: Claims 9 and 10 Are Rendered Obvious by Cho Alone or in Combination with Kim, Yamamoto, and/or Blangero

1. Dependent Claim 9

- a. *[Element 9.0]: The lithium-ion secondary battery according to claim 6,*

Cho, alone or with Kim and/or Yamamoto, renders claim 6 obvious. *See supra*, § X.E.1.

- b. *[Element 9.1]: wherein a relative value of a concentration of the titanium is greater than or equal to 0.05 and less than or equal to 0.4 when the surface of the positive electrode active material particle is subjected to an XPS analysis and a concentration of cobalt is defined as 1.*

Cho, alone or with Kim, Yamamoto, and/or Blangero, renders this limitation obvious. *See supra*, § X.D.2.b.

2. Dependent Claim 10

- a. *[Element 10.0]: The lithium-ion secondary battery according to claim 6,*

Cho, alone or with Kim and/or Yamamoto, renders claim 6 obvious. *See supra*, § X.E.1.

- b. *[Element 10.1]: wherein a relative value of a concentration of the magnesium is greater than or equal to 0.4 and less than or equal to 1.5 when the surface of the positive electrode active material particle is subjected to*

an XPS analysis and a concentration of cobalt is defined as 1.

Cho, alone or with Kim, Yamamoto, and/or Blangero, renders this limitation obvious. *See supra*, § X.D.3.b.

XI. SECONDARY CONSIDERATIONS

Petitioner is unaware of any evidence of alleged secondary indicia that would support non-obviousness. To the extent Patent Owner subsequently presents such evidence, Petitioner respectfully requests the right to respond.

XII. CONCLUSION

Claims 1–10 of the '660 Patent are obvious for the reasons set forth above. Because there is a reasonable likelihood that Petitioner will prevail regarding each of these Challenged Claims, review of claims 1–10 is accordingly requested.

Dated: September 4, 2023

Respectfully submitted,

/Yimeng Dou/

Yimeng Dou (Reg. No. 69,770)

**Attorney for Petitioner Amperex
Technology Ltd.**

CERTIFICATE OF COMPLIANCE

This Petition complies with the type-volume limitations as mandated in 37 C.F.R. § 42.24, totaling 13,981 words. Counsel has relied upon the word count feature provided by Microsoft Word.

/Yimeng Dou/

Yimeng Dou (Reg. No. 69,770)

CERTIFICATE OF SERVICE

The undersigned hereby certifies that a copy of the foregoing document with accompanying exhibits, as listed in Petitioner's Exhibit List on pages iv–vii of this document, was served via overnight delivery directed to the attorney/agent of record for the patent as identified on USPTO PAIR and associated with USPTO Customer No. 26171 at the following address:

FISH & RICHARDSON P.C. (DC)
P.O. BOX 1019
MINNEAPOLIS, MN 55440-1019
UNITED STATES

A courtesy copy was also served via electronic mail and FTP on the attorneys of record listed below for the following related matter:

Ahmed J. Davis
adavis@fr.com
Menglin Sun
msun@fr.com
FISH & RICHARDSON P.C.
1000 Maine Avenue, SW, Suite 1000
Washington, DC 20024

Christina Brown-Marshall
brown-marshall@fr.com
Fish & Richardson P.C.
1180 Peachtree St., NE, 21st Floor
Atlanta, GA

David Barkan
barkan@fr.com
FISH & RICHARDSON P.C.
500 Arguello Street, Suite 400
Redwood City, CA 94063

Excylyn J. Hardin-Smith
hardin-smith@fr.com
FISH & RICHARDSON P.C.
7 Times Square, 20th Floor
New York, NY 10036

/Yimeng Dou/

Yimeng Dou (Reg. No. 69,770)