

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE PATENT TRIAL AND APPEAL BOARD

In re *Inter Partes* Review of:

U.S. Patent No. 8,558,223

DECLARATION OF BARRY P. RAND, PH.D.

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I. INTRODUCTION

1. I, Barry P. Rand, Ph.D., declare as follows:

2. I have been retained as a technical consultant on behalf of Samsung Display Co., Ltd. (“Petitioner”), who I understand is the petitioner in the present proceeding. I have been asked to consider whether the references listed as Exhibits 1005–1015 below disclose and/or render obvious the limitations recited in claims 1–4, 6, and 8–14 of U.S. Patent No. 8,558,223 (the “’223 patent”). I have also been asked to consider the state of the art and the prior art available before the time of the alleged invention of the ’223 patent. My opinions are provided in this declaration.

3. To the best of my knowledge, I have no financial interest in Petitioner. I have been informed that a company known as Pictiva Displays International Ltd. (“Pictiva” or “Patent Owner”) purports to own the ’223 patent. To the best of my knowledge, I have no financial interest in Pictiva and, to the best of my recollection, I have had no contact with Pictiva or the named inventors of the ’223 patent, Günter Schmid, Ralf Krause, Andreas Kanitz, Jürgen Adler, Stefan Seidel, and Arvid Hunze. To the best of my knowledge, I similarly have no financial interest in the ’223 patent. To the extent any mutual funds or other investments that I own have a financial interest in the Petitioner, the Patent Owner, or the ’223 patent, I am not aware of, nor do I have control over, any financial interest that would affect or bias my judgment.

4. I am being compensated at my standard consulting rate for my time.

My compensation is in no way contingent on the results of these or any other proceedings relating to the '223 patent.

II. BACKGROUND AND QUALIFICATIONS

5. My qualifications and professional experience are described in my *curriculum vitae*, a copy of which is provided as Exhibit 1004. The following is a brief summary of my relevant qualifications and professional experience.

6. I am currently a Professor at Princeton University, jointly appointed between the Department of Electrical and Computer Engineering and the Andlinger Center for Energy and the Environment. I have been employed by Princeton University since 2013.

7. Broadly speaking, my research is in the area of electronic materials and devices, with a specialization in the study of numerous classes of thin film semiconductors. The most commonly employed semiconductors are those based upon conjugated molecules, metal oxides, and metal halide perovskites. The materials and devices with which I work on a regular basis have application to a host of electronic devices and systems. The devices most commonly studied in my research are light emitting diodes (LEDs) and solar cells. My research group strives to understand the operation of devices through consideration of the chemical, structural, electronic, and optical properties of the constituent materials. This work

draws from the fields of chemistry, materials science, physics, and electrical engineering.

8. I received a B.E. in electrical engineering from The Cooper Union for the Advancement of Science and Art in 2001. I then received my Master of Arts and Ph.D. degrees in electrical engineering from Princeton University, in 2003 and 2007, respectively. My Ph.D. thesis advisor was Prof. Stephen R. Forrest.

9. From 2007 to 2013, I was at imec in Leuven, Belgium, an independent research center dedicated to the study of microelectronic materials, devices, and systems. I was ultimately a principal scientist, appointed in their “large area electronics” division, which conducts research on large area solar cells, imagers, circuits, and LED displays.

10. I have authored approximately 200 peer-reviewed journal publications and hold 24 U.S. patents. I have given over 150 invited talks at conferences, other universities, national labs, or companies.

11. I have received numerous awards over the course of my career, including the 3M Nontenured Faculty Award (2014), DuPont Young Professor Award (2015), DARPA Young Faculty Award (2015), ONR Young Investigator Program Award (2016), and the Gordon and Betty Moore Foundation Experimental Physics Investigators Initiative award (2023).

12. Since 2019, I have been an editor of *Organic Electronics*, a journal

dedicated to reporting results in the area, including organic LEDs.

III. MATERIALS REVIEWED

13. I am not an attorney and offer no legal opinions, but in my work, I have had experience studying and analyzing patents and patent claims from the perspective of a person skilled in the art as well as an inventor.

14. In preparing this declaration, I reviewed the '223 patent, including the claims of the patent in view of the specification, and I have reviewed the prosecution history of the '223 patent and numerous prior art and technical references from the time of the alleged invention. More specifically, I have reviewed each of the following:

Exhibit	Description
1001	U.S. Patent No. 8,558,223
1002	File History for U.S. Patent No. 8,558,223
1004	<i>Curriculum Vitae</i> of Barry P. Rand, Ph.D.
1005	PCT Application Publication No. WO 2005/086251 (“Werner”) (English translation)
1006	PCT Application Publication No. WO 2005/086251 (“Werner”) (Original German)
1007	J.W. Ma et al., <i>Organic light-emitting diodes based on new n-doped electron transport layer</i> , Synthetic Metals 158, 810–814 (2008) (“Ma”)
1008	Max Shtein et al., Micropatterning of small molecular weight organic

Exhibit	Description
	semiconductor thin films using organic vapor phase deposition, J. Appl. Phys. 93, 4005–4016 (2003) (“Shtein”)
1009	U.S. Patent Application Publication No. 2007/0249148 (“Werner II”)
1010	U.S. Patent Application Publication No. 2008/0258610 (“Ikeda”)
1011	U.S. Patent Application Publication No. 2007/0181876 (“Itai”)
1012	F. Albert Cotton et al., <i>Studies of Tetrakis(trifluoroacetate) Dirhodium. 2. † A Pi Complex of Hexamethylbenzene with Tetrakis (trifluoroacetate) Dirhodium(II,II)</i> , 18 Organometallics 2724–2726 (1999) (“Cotton 1999”)
1013	Abhishek P. Kulkarni et al., <i>Electron Transport Materials for Organic Light-Emitting Diodes</i> , 16 Chem. Mater. 4556–4573 (2004) (“Kulkarni”)
1014	U.S. Patent Application Publication No. 2005/0129978 (“Nakashima”)
1015	Bernard Geffroy et al., <i>Organic light-emitting diode (OLED) technology: materials, devices and display technologies</i> , 55 Polym Int 572–582 (2006) (“Geffroy”)

IV. RELEVANT LEGAL STANDARDS

15. I am not an attorney. For the purposes of this declaration, I have been informed about certain aspects of the law that are relevant to forming my opinions. I have applied the following understanding of the law:

16. I have been informed that a patent claim may be “anticipated” if each element of that claim is present either explicitly or inherently in a single prior art

reference, and that the elements should be arranged in the reference as in the claim.

Petitioner's counsel has informed me that for a claimed limitation to be inherently present, the prior art need not expressly disclose the limitation, so long as the claimed limitation necessarily flows from a disclosure in the prior art.

17. I have been informed that a patent claim can be considered to have been obvious to a person of ordinary skill in the art at the time the application was filed. This means that, even if all of the requirements of a claim are not found in a single prior art reference, the claim is not patentable if the differences between the subject matter in the prior art and the subject matter in the claim would have been obvious to a person of ordinary skill in the art at the time the application was filed.

18. I have been informed that a determination of whether a claim would have been obvious should be based upon several factors, including, among others:

- the level of ordinary skill in the art at the time the application was filed;
- the scope and content of the prior art; and
- what differences, if any, existed between the claimed invention and the prior art.

19. I have been informed that a single reference can render a patent claim obvious if any differences between that reference and the claims would have been obvious to a person of ordinary skill in the art. Alternatively, the teachings of two or more references may be combined in the same way as disclosed in the claims, if such

a combination would have been obvious to one having ordinary skill in the art. In determining whether a combination based on either a single reference or multiple references would have been obvious, it is appropriate to consider, among other factors:

- whether the teachings of the prior art references disclose known concepts combined in familiar ways, and when combined, would yield predictable results;
- whether a person of ordinary skill in the art could implement a predictable variation, and would see the benefit of doing so;
- whether the claimed elements represent one of a limited number of known design choices, and would have a reasonable expectation of success by those skilled in the art;
- whether a person of ordinary skill would have recognized a reason to combine known elements in the manner described in the claim;
- whether there is some teaching or suggestion in the prior art to make the modification or combination of elements claimed in the patent; and
- whether the innovation applies a known technique that had been used to improve a similar device or method in a similar way.

20. Petitioner's counsel has informed me that one of ordinary skill in the art has ordinary creativity and is not an automaton. Petitioner's counsel has informed

me that in considering obviousness, it is important not to determine obviousness using the benefit of hindsight derived from the patent being considered.

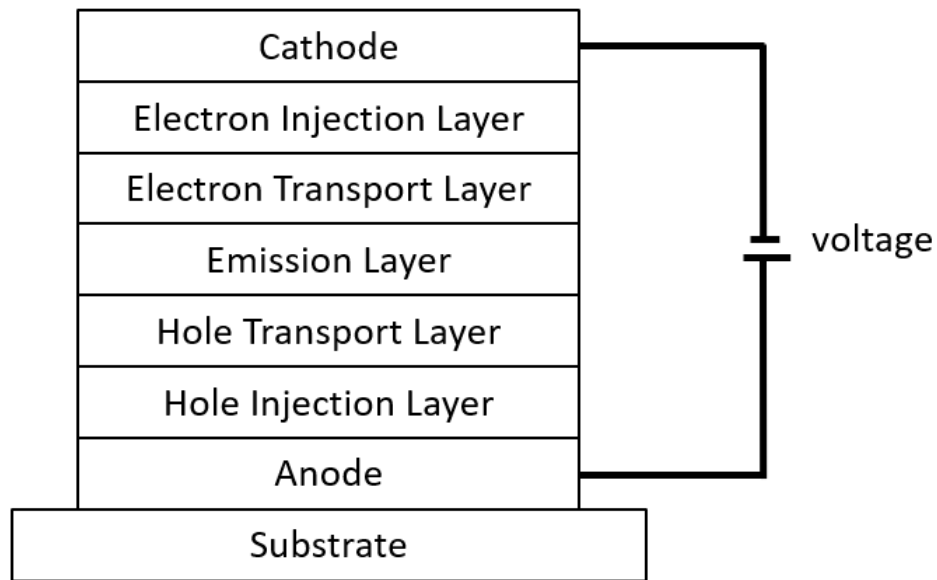
V. TECHNOLOGY BACKGROUND

21. For this declaration, I have assumed that the priority date of the challenged claims is September 25, 2009.¹ Thus, for purposes of this analysis, I assume that the time of the purported invention of the '223 patent was September 25, 2009, and have provided an overview of the background of the relevant technology at that time.

22. Before September 25, 2009, organic light-emitting devices (OLEDs) had been of considerable interest due to high-brightness light emission at low voltage and advantages of reducing the thickness, weight, size, and power consumption of the devices. Itai (US 2007/0181876) (Ex.1011), [0005].

23. OLEDs typically have thin multi-layers, which may include (1) a substrate, (2) an anode, (3) a hole injection layer, (4) a hole transport layer, (5) a light emitting layer, (6) electron transport layer, (7) electron injection layer, and (8) a cathode, as illustrated below.

¹ See *infra* Section VI.A.



This multi-layer structure for an OLED was used before 2009.

24. Before 2009, it was well-known to use a metal complex and an organic compound as a dopant and a matrix material, respectively, to improve electron conductivity for the electron transport layer. For example, Novaled AG carried out extensive research on the use of a metal complex as an n-dopant for an organic semiconducting matrix material for OLEDs. *See, e.g.*, U.S. Patent Application Publication No. 2007/0249148 (Ex.1009).

25. Before 2009, there were a number of well-known metal complexes that were used to improve electron conductivity for the electron transport layer and/or the electron injection layer. For example, $W_2(hpp)_4$, (which is disclosed in the '223 patent) or metal complexes with rhodium, molybdenum, chromium, lithium or

cesium were well known for use in OLED systems. *See e.g.*, Cotton 1999 (Ex.1012).

26. Before 2009, many of the organic compounds disclosed in the '223 patent were used as electron transport materials for the electron transport layer and the electron injection layer. For example, TPBI (Compound III)², PBD (Compound IV), BCP (Compound V), BPhen (Compound VI), and OXD-7 (Compound XIII) were known before 2009. *See generally*, Kulkarni (Ex.1013); Nakashima (Ex.1014), [0086].

27. Before 2009, a number of different methods of forming thin films were known. One such method was the vapor deposition method was commonly used for forming thin films in the OLEDs. The method consists of placing the materials in crucibles which are heated to 100–500 °C, under vacuum, thus inducing evaporation of the materials. This technique was already employed in commercial applications before 2006. *See e.g.*, Geffroy (Ex.1015) at 580.

² I observe that TPBI is misdrawn in the '223 patent. The three heterocyclic structures are each missing a double bond.

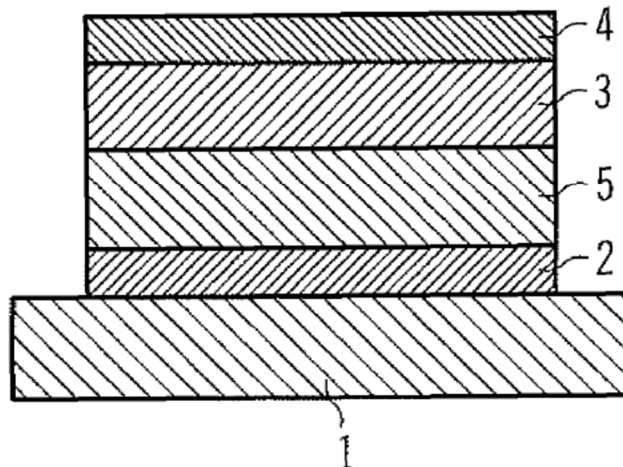
VI. OVERVIEW OF THE '223 PATENT

A. Summary

28. The '223 patent claims priority to a PCT application (PCT/DE/2009/001359) filed on September 25, 2009.

29. The '223 patent relates to organic electronic components, comprised of at least a “substrate, a first electrode, a second electrode, and an electron-conducting layer”. '223 patent, Abstract. This component system is illustrated by Figure 1 of the patent, which provides: showing “a layer sequence comprising a substrate 1, on which a first electrode 2 and a second electrode 4 are arranged. The electron-conducting layer 3 and the emitting layer 5 are located between the two electrodes.” '223 patent, 15:15–18.

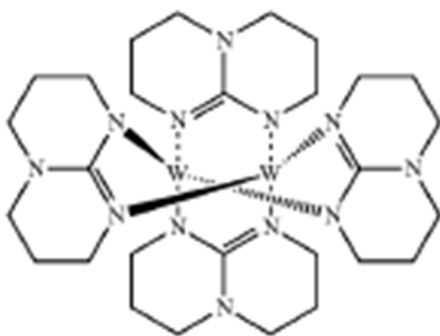
FIG 1



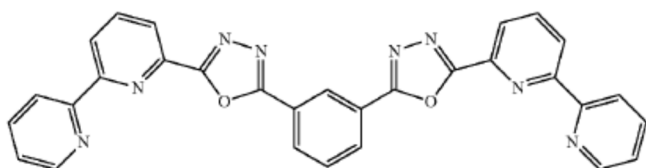
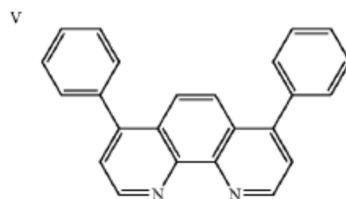
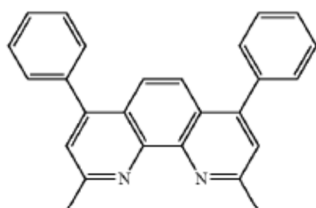
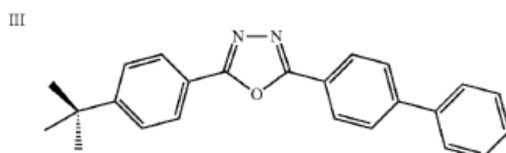
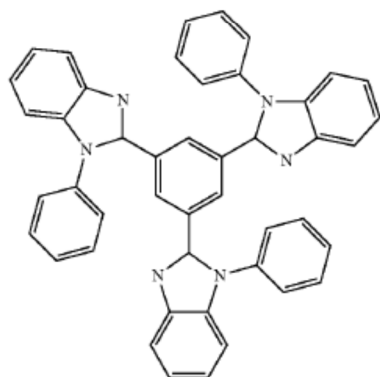
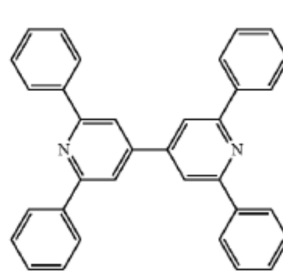
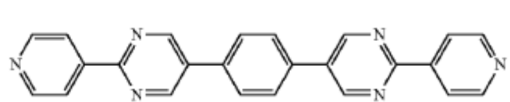
Id., Fig. 1.

30. As relevant to the claims, the '223 patent discloses that “the electron-

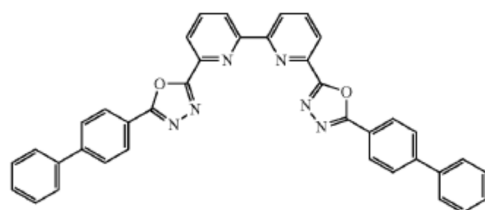
conducting layer” comprises a metal complex and an organic compound. *Id.*, 1:57–59. The ’223 patent discloses that the metal complex has existing ligands and a metal atom. *See id.* 2:17–27. In particular, “[m]etal complexes having two central atoms are particularly well suited for the formation of chains” (*id.*, 2:49–50) and that “[i]n this case, each of the two central atoms has a coordination site without a steric hindrance being generated.” *Id.*, 2:45–47. One particular example of a metal complex is referred to as $W_2(TBD-A)_4$, which is more conventionally known as $W_2(hpp)_4$ (*id.* at 3:22–38):



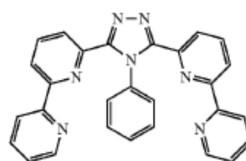
31. The organic compound “comprises a heteroaromatic compound which is conjugated with an aromatic compound via a C—C bond.” *Id.*, 4:2–4. Various exemplar compounds meeting this structural limitation are provided, but “[t]he compounds illustrated in the structures I to XIII are particularly well suited as an organic compound for the electron-conducting layer.” *Id.*, 7:43–45. Compounds I to XIII are listed below:



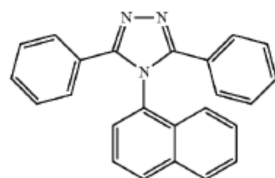
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VIII



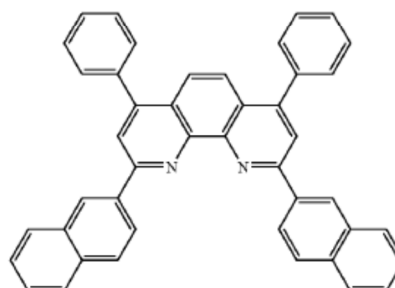
IX



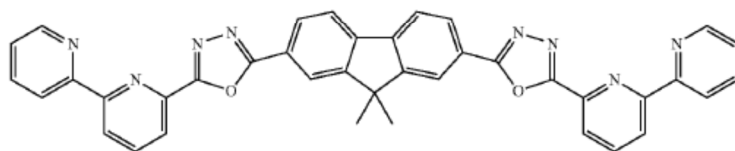
X



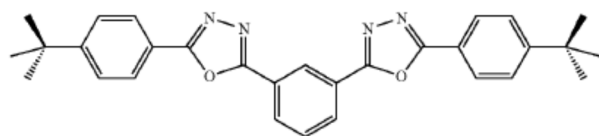
XI



XII



XIII



Id., 5:16–8:42. Several of these compounds are known by their abbreviations: for example, Compound III is known as TPBI.³ Compound IV is known as PBD.

³ As I described above, the drawings of TPBI in Fig. 3, column 5 and in Claim 6 in the '223 patent are missing a number of double bonds in each of the heterocyclic structures. Given that the '223 patent states that Compound III is TPBI ('223 patent, 16:12–14 (“The third structural formula [in Fig. 3] shows TPBI (1,3,5-tris(1-phenyl-1H-benzimidazole-2-yl)benzene”), I have analyzed claim 6 under the assumption that Compound III is intended to be TPBI.

Compound V is known as BCP. Compound VI is known as BPhen. Compound XIII is known as OXD-7.

32. The '223 patent also discloses the well-known fact that “[b]y virtue of the coordination of the organic compound on the metal complexes, and the associated overlap of the orbitals, additional electrons can be transferred from the metal to the ligand via a metal complex-ligand-electron transfer (metal-ligand-charge-transfer complex).” (*id.*, 2:6–10) and that “[t]he coordination of the organic compound to the central atom can be effected directly via a further atom or else also via an aromatic system.” *Id.*, 2:19–21.

33. This electron-conducting layer can be obtained by joint vaporization of the metal complex with the organic compound. *Id.*, 16:37–44. The '223 patent discloses one method for manufacturing such an organic electronic component as follows:

providing a substrate as method step A), applying a first electrode in method step B), depositing an electron-conducting layer on the substrate as method step C), applying a second electrode in method step D), wherein the electron-conducting layer is deposited by simultaneous vaporization of a metal complex and an organic compound.

Id., 13:14–22. “In a further method variant, the organic compound does not coordinate to the metal complex prior to vaporization.” *Id.*, 14:9–10. The '223 patent discusses production mechanisms to achieve the joint vaporization:

The metal complex and the organic compound can for example be vaporized from two different vessels which are spatially separated from each other. However, it is also possible to put the two compounds into one vessel without a reaction or coordination taking place amongst the compounds in the solid phase and so that the compounds then being vaporized from the joint vessel.

Id., 14:11–17.

34. The '223 patent further discloses that “[i]n an embodiment of the organic electronic component, at least parts of the organic compounds bridge two metal complexes together, so that a chain-like structure is formed and/or at least parts of the organic compounds bridge more than two metal complexes together, so that a network-like structure is formed.” *Id.*, 11:11–16.

35. In particular, the '223 patent observes that “compounds I to XIII [explained above] allow not only for the formation of two-dimensional chains, but, by virtue of their multiplicity of coordination sites, they also allow for the formation of three-dimensional networks. In this case, an organic compound coordinates to more than two metal complexes.” *Id.*, 7:48–53.

36. The '223 patent discloses that

[b]y suitable selection of the metal complexes, for example binuclear metal complexes, and suitable selection of the organic compounds such as for example the compounds I to XXIII, the joint vaporization of the metal complex with the organic compound in the gas phase or on the deposited surface results in interactions, so that the compounds

coordinate to each other.

'223 patent, 11:17–23. The '223 patent explains that “[t]his coordination can result in the formation of two-dimensional chains or three-dimensional networks.” *Id.*, 11:24–26. The '223 patent also discloses that “[t]he degree of cross-linking and thus the formation of network-like or chain-like structures can be controlled by the ratio of metal complex to organic compound.” *Id.*, 13: 65–67.

37. The '223 patent includes two independent claim (claims 1 and 10) and twelve dependent claims (claims 2–9 and 11–14).

B. Prosecution History

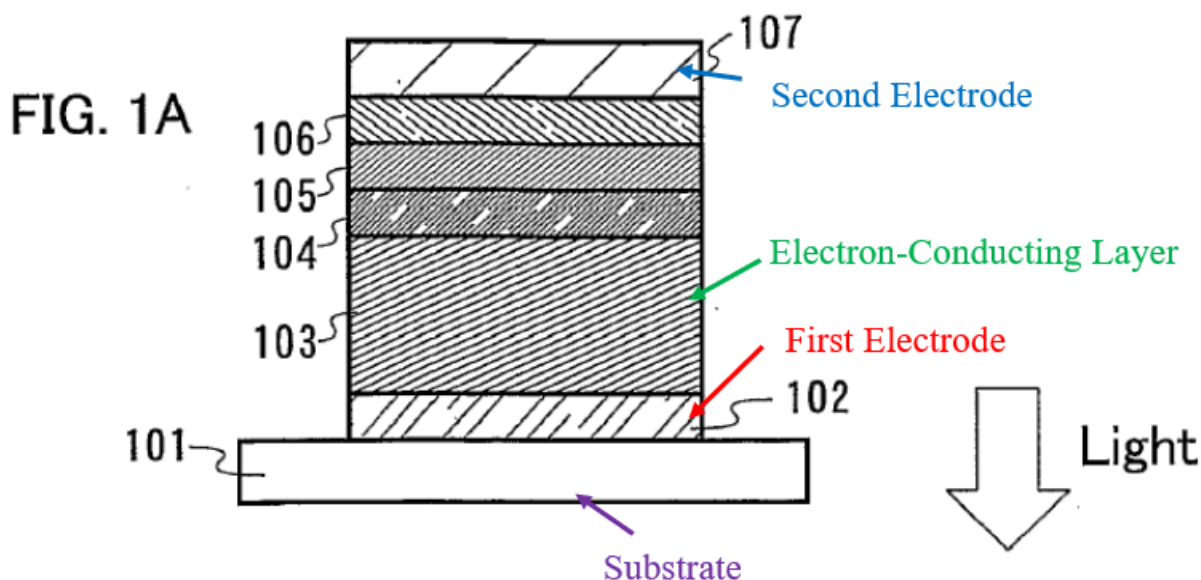
38. I have reviewed the prosecution history of Application No. 12/713,220 that led to the '223 patent.

39. I understand that during prosecution of the U.S. Patent Application No. 13/121,090 that issued as the '223 patent, prosecution claims 1–4 and 9–15 were rejected under 35 U.S.C. 102(e) as being anticipated by U.S. Patent Publication 2008/0258610 A1 (“Ikeda”).

40. The Examiner observed that Ikeda disclosed an organic electrode component, comprising: a substrate 101, a first electrode 102, a second electrode 107, an electron-conducting layer 103 which is arranged in such a way that is electrically conductively connected to at least on one of the electrodes 102/107, wherein the electron-conducting layer 103 can be obtained by joint vaporization of

a metal complex, which comprises a central metal atom, with an organic compound.

Ex.1002, 811. These elements are depicted in Ikeda's Fig. 1A, which I have annotated.



Ikeda, Fig. 1A (annotated).

41. Prosecution claim 5 depending from prosecution claim 1 added the element “wherein the organic compound comprises a heteroaromatic compound which is conjugated with an aromatic compound via a C-C bond.” *Id.*, 14. The Examiner found that this claim comprised allowable subject matter.

42. It is my opinion that the Examiner did not address Ikeda's disclosures regarding layer 106 (see Ikeda, paragraphs [0071]–[0073] and [0077]), which is also an electron-conducting layer arranged in such a way that it is electrically conductively connected to at least on one of the electrodes 102/107, and which can be obtained by

joint vaporization. Layer 106 is comprised of various metal complexes (*see* [0071]) and may also contain additional compounds (*see* [0073], including PBD (Compound IV in the '223 patent); OXD-7 (Compound XIII in the '223 patent); BPhen (Compound VI in the '223 patent); and BCP (Compound V in the '223 patent)). It is my opinion that each of these compounds is a heteroaromatic compound which is conjugated with an aromatic compound via a C-C bond and each was specifically claimed in prosecution claim 7.

43. I understand that the applicant did not dispute the Examiner's findings regarding Ikeda. Rather, the applicant amended prosecution claims 1 and 11 (the only two independent claims) "to include the limitations of claim 5." Ex.1002, 836. Following this amendment, the claims were allowed. Ex.1002, 1131–1134.

44. Thus, the claims of the '223 patent were only allowed after the independent claims were amended to require that "the organic compound comprises a heteroaromatic compound which is conjugated with an aromatic compound via a C-C bond." Although the Examiner found that "[t]he prior art of record does not disclose, make obvious, or otherwise suggest the structure of the applicant's together with the other limitations of the independent claims," the Examiner did not have the benefit of other prior art, including the Werner and Ma references, which were not of record during prosecution and which specifically disclose such an organic compound, along with every other element of the independent claims (among others), discussed below.

C. Level of Ordinary Skill in the Art

45. It is my understanding that factors defining the level of ordinary skill in the art include: (1) the types of problems encountered in the art; (2) the prior art solutions to those problems; (3) the rapidity with which innovations are made; (4) the sophistication of technology; and (5) the educational level of active workers in the field.

46. In my opinion, the person of ordinary skill in the art (“POSA”) has a university degree in chemistry and additional expertise or a second university degree in the field of electrical engineering, particularly optoelectronics, or alternatively a university degree in electrical engineering and additional expertise or a second university degree in the field of chemistry. A POSA has spent several years studying the structure and function of organic optoelectronic components, in particular OLEDs, and has detailed knowledge of the chemical structure of light-emitting organic layers and the transport of charge carriers to these layers. In this respect, a POSA works at the interface between electrical engineering/physics (charge carrier transport and light emission processes in optoelectronic components) and chemistry, in particular organic chemistry (materials and layer stack combinations suitable).

47. I applied this definition of a POSA in forming my opinion in this declaration.

D. Claim Construction

48. I am informed that claims in an IPR are construed in accordance with the ordinary and customary meaning of such claim as understood by one of ordinary skill in the art and the prosecution history.

49. In my opinion, there are no specialized constructions that are necessary in order to understand the claims. Thus, I have applied the ordinary and customary meaning of such claim.

50. As discussed below in Ground II, I am informed that Patent Owner has made certain assertions regarding the scope of the claims. I have set forth my understanding of each of those assertions with respect to the relevant claims, and my opinions are offered in the context of Patent Owner's assertions.

VII. OVERVIEW OF THE PRIOR ART

A. Werner (Ex.1005, Ex.1006)

51. PCT Application Publication No. WO 2005/086251 ("Werner") was published on September 15, 2005, which is more than one year before the September 25, 2009, filing of the PCT application that led to the '223 patent. Although the original publication was in German, I have reviewed an English translation (Ex.1005), provided to me by Petitioner's counsel. I have not substantively reviewed the original publication in German (Ex.1006).

52. Werner is directed to "an electronic device with an organic semiconducting material which is doped with a metal complex as an n-dopant."

Werner, 1:14–16. Werner discloses that

[t]he layer of the organic semiconducting material doped with the n-dopants according to the invention is applied to an ITO layer (indium tin oxide) arranged on a glass substrate. After applying the n-doped organic semiconductor layer according to the invention, a metal cathode is applied, for example, by vapor-deposition of a suitable metal to produce an organic light-emitting diode.

Id. 61:17–22.

53. Werner discloses that “the metal complex of the invention is a polynuclear metal complex” (*id.*, 11:7–8) and specifically discloses $W_2(hpp)_4$. *Id.* 40:59–64 (“ M_2hpp_4 with M equals Cr, Mn, Fe, Co, Ni, Cu, Zn, Mo, or *W*.”) (emphasis added). Werner discloses BPhen as an organic compound for the n-doped organic semiconductor layer. *Id.*, 55:5–6.

54. Werner discloses that “[t]he doping of the respective matrix material with the n-dopants according to the invention can be carried out by one or a combination of the following methods” and specifically discloses “[c]o-evaporation in a vacuum with one source for the matrix material and one for the dopant” and “[p]reparation of a solution of matrix molecules and dopants and subsequent formation of a layer from this solution by conventional methods such as solvent evaporation or spin-coating” *Id.*, 56:13–30. I discuss further aspects of Werner below.

B. Ma (Ex.1007)

55. J.W. Ma et al., *Organic light-emitting diodes based on new n-doped*

electron transport layer, *Synthetic Metals* 158, 810–814 (2008) (“Ma”) is an article published in *Synthetic Metals* and available online as of August 29, 2008, which is more than a year before the September 25, 2009, filing of the PCT application that led to the ’223 patent.

56. Ma is directed to “[o]rganic light-emitting diodes with 8-hydroxy-quinolinato lithium [Liq] doped 4,7-diphenyl-1, 10-phenanthroline [BPhen] as electron transport layer (ETL).” Ma, 810, Abstract. The OLED of Ma comprises an anode, as Ma discloses that “[g]lass coated with ITO . . . was used as starting substrate,” which also included the ITO anode. “Bphen:y wt.% Liq are used as n-doping (ETL).” Ma, 811. “N,N’-diphenyl-N, N’-bis(1,1’-biphenyl)-4,4’-diamine (NPB) and Alq₃ are used as interlayer and emission layer (EML), respectively, while LiF and Al are used as electron injection layer and cathode, respectively.” Ma, 811.

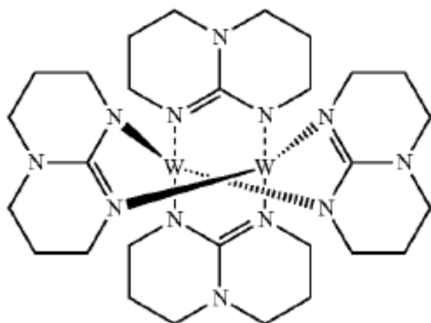
57. Ma further discloses that “a 50 nm-thick *BPhen:Liq ETL* was co-deposited on the *EML*. In the co-deposition process, organic sources were independently controlled. . . . All the layers (organic layers, and Al electrode) of the devices were fabricated by conventional thermal evaporation in a high vacuum chamber with a base pressure of 1×10^{-5} Torr.” *Id.* I discuss further aspects of Ma below.

VIII. CLAIMS ANALYSIS

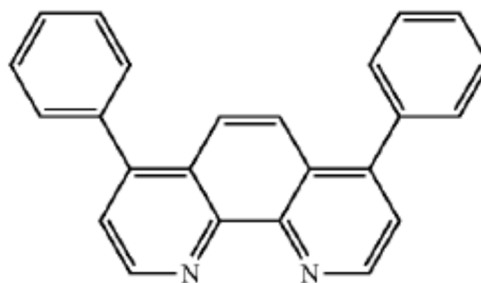
A. Ground I: Claims 1–4, 6, and 8–14 Are Rendered Obvious by Werner

58. It is my opinion that Werner renders obvious all of the elements of claims 1–4, 6 and 8–14 of the '223 patent, as discussed below. Further, it is my opinion that given the identical arrangement in Werner of each disclosed or suggested element, as articulated in Ground I below, a POSA would have been motivated to arrive at the claims as a whole based on Werner's disclosure and a POSA's knowledge.

59. As discussed below, it is my opinion that Werner discloses an OLED structure including an anode, a cathode, and an n-doped organic semiconductor layer. In my opinion, the n-doped organic semiconductor layer can be an electron-conducting layer and can be formed by joint vaporization of a metal complex as an n-dopant and an organic compound as a matrix material. Specifically, Werner discloses that the materials for this layer may include (i) the metal complex $W_2(hpp)_4$, which has two central metal (W) atoms and is in fact the same metal complex that is used in each embodiment of the '223 patent; and an (ii) the organic compound BPhen, which comprises a heteroaromatic compound which is conjugated with an aromatic compound via a C—C bond, and which is accordingly identified in the '223 patent as Compound VI.



W₂(hpp)₄ or W₂(TBD-A)₄
(’223 patent, 3:21–38)



BPhen
(Werner, 54:11–13)

1. Independent Claim 1

60. As discussed in more detail below, it is my opinion that Werner discloses all of the elements (or limitations) of Independent claim 1.

a) **Preamble: An organic electronic component, comprising:**

61. I have been informed that the preamble to a claim may or may not be viewed to be a limitation (or element) to the claim. It is my opinion that, to the extent the preamble is limiting, Werner discloses it. In the background of the invention, Werner explains that the “[t]he invention relates . . . to an electronic device with an organic semiconducting material doped with a metal complex as an n-dopant.” Werner, 1:9–16. Werner further discloses that “[t]he invention relates . . . to an organic semiconducting material containing an organic matrix material and a metal complex as an n-dopant.” *Id.* Werner also explains that one of the uses of the organic semiconducting material doped in each case with the n-dopants is in an organic light emitting diode. Werner, 2:21–30. Therefore, it is my opinion that Werner discloses an

organic electronic component.

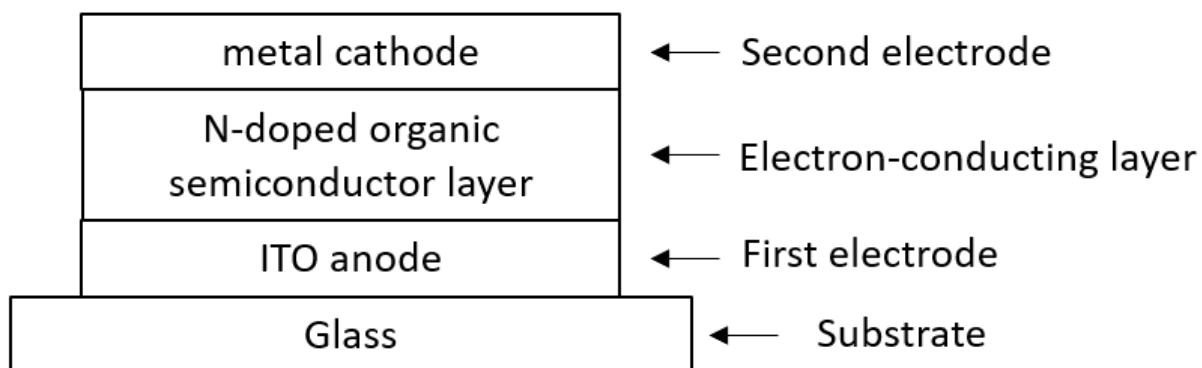
- b) **Element 1[a]: a substrate, a first electrode, a second electrode, an electron-conducting layer which is arranged in such a way that it is electrically conductively connected to at least one of the electrodes,**

62. It is my opinion that Werner discloses this element.

63. In my opinion, Werner discloses an organic light-emitting diode including a glass substrate, an ITO layer (*a first electrode*), a metal cathode (*a second electrode*), and a n-doped organic semiconductor layer, which can be used for electron transport (*an electron-conducting layer*).

The layer of ***organic semiconducting material*** doped with the n-dopant according to the invention is applied to an ***ITO layer*** (indium tin oxide) arranged on a ***glass substrate***. After applying the n-doped organic semiconductor layer according to the invention, a ***metal cathode*** is applied, for example, by vapor-deposition of a suitable metal to produce an organic light-emitting diode.

Werner, 61:17–22 (emphasis added). This structure is schematically shown below:



64. In Werner, the n-doped organic semiconductor layer is an electron-conducting layer. **First**, Werner discloses that

the area containing a metal complex according to the invention or consisting essentially or entirely of it [the metal complex] can be **electrically conductively** contacted with an organic semiconducting material and/or an inorganic semiconducting material, for example, arranged on such a substrate.

Werner, 57:34–58:2 (emphasis added). **Second**, Werner states that “[t]he present invention describes suitable n-dopants for organic semiconducting materials such as **electron transport materials** commonly used in electronic devices” *Id.* at 52:34–53:3 (emphasis added). **Third**, Werner explicitly states that its techniques are not limited to particular layers but are instead broadly applicable: “The use of the dopants according to the invention is not limited to the above examples; in particular, the layer structures can be supplemented or modified by introducing additional suitable layers.” *Id.* at 59:30–33. **Fourth**, Werner’s invention accommodates additional layers. *Id.* at 61:26–28 (“It is understood that additional layers may be provided between the

individual layers mentioned depending on the application.”). Therefore, it is my opinion that a POSA would have understood that Werner’s doping technique using a metal complex and organic compound would have been used in an electron-conducting layer, such as an electron transport layer.

65. In my opinion, because the n-doped organic semiconductor layer (*the electron conducting layer*) is between the *first electrode* (the ITO layer) and the *second electrode* (the metal cathode), in order to produce a light-emitting diode, the n-doped organic semiconductor layer would have to be arranged in such a way that is *electrically conductively connected to at least one of the electrodes*.

c) Element 1[b]: wherein the electron-conducting layer is obtained by joint vaporization of a metal complex, which comprises a central metal atom, with an organic compound,

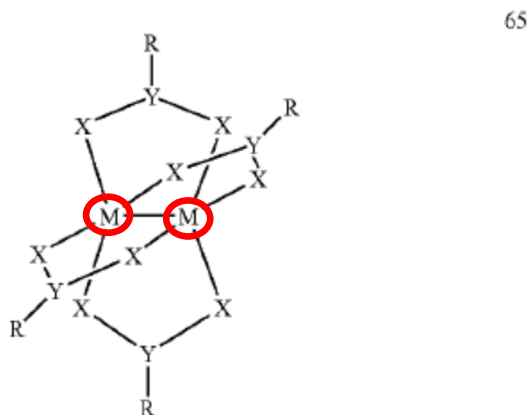
66. It is my opinion that Werner discloses this element.

67. **First**, it is my opinion that Werner discloses that the *electron-conducting layer* (n-doped organic semiconductor layer) is comprised of a metal complex and an organic compound (i.e., the matrix material). Werner, 1: 14–16.

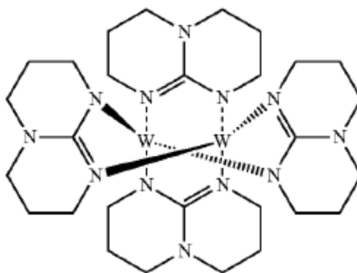
68. **Second**, Werner discloses that the *metal complex comprises a central metal atom*. *Id.*, 10:14–19. Werner discloses that “the metal complex according to the invention is a multinuclear metal complex” (*id.*, 11:7–8) and specifically discloses “a so-called paddlewheel complex [65], in which two *central metal atoms*, in particular transition metal central atoms are bridged by 1, 2, 3, 4 or more bidentate ligands each

binding one ligand atom to both metal central atoms.” *Id.*, 11:26–29 (emphasis added).

An exemplary paddlewheel complex (65) with two central metal atoms (red circles) is shown below:

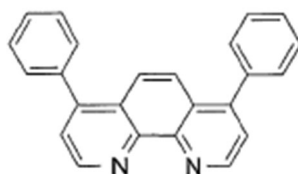


Id., 12:1–3 (annotated). Werner specifically discloses $W_2(hpp)_4$ as one of the examples of the metal complex. Werner, 60:20–21 (“ M_2hpp_4 with M equals Cr, Mn, Fe, Co, Ni, Cu, Zn, Mo, or *W*”); *see also* 13:20–21 (defining hpp as “(*hpp: anion of 1,3,4,6,7,8-hexahydro-2H-pyrimido[1,2-a]pyrimidine*)”) (emphasis added). $W_2(hpp)_4$ is tetrakis(hexahydropyrimidinopyrimidine)ditungsten(II), known as ditungsten tetra(hpp), which is the only metal complex used in all the embodiments of the ’223 patent. ’223 patent, 14:22–46, 16:61–18:45, Figs. 5–8. $W_2(hpp)_4$ is referred to as $W_2(TBD-A)_4$ in the ’223 patent, based on the structure provided for $W_2(TBD-A)_4$, as reproduced below:



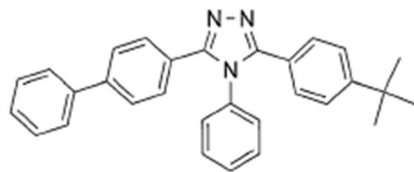
'223 patent, 3:21–38. $W_2(TBD-A)_4$ and $W_2(hpp)_4$ are the identical compounds.

69. **Third**, it is my opinion that Werner discloses *an organic compound*, which Werner refers to as the matrix material. Werner, 52:33–55:25. For example, Werner discloses that “[p]henanthrolines, which can be substituted or unsubstituted, in particular aryl-substituted, such as phenyl or naphthyl-substituted, can also be used as matrix materials. In particular, *BPhen* can be used as the matrix material.” *Id.*, 55:3–6 (emphasis added). The structure of BPhen is disclosed as follows:



BPhen = bathophenanthroline
(4,7-Diphenyl-1,10-phenanthroline)
C₂₄H₁₆N₂

Id., 54:11–13. As another example, Werner discloses that 3-(4-biphenyl)-4-phenyl-5-tert-butylphenyl-1,2,4-triazole (C₃₀H₂₇N₃) as a triazole that can be used as the matrix material. The structure of this compound is disclosed as follows:



3-(4-Biphenyl)-4-phenyl-5-tert-butylphenyl-1,2,4-triazoles

C₃₀H₂₇N₃

Werner, 55:15–17. Werner also discloses that “[h]eteroaromatics, in particular triazoles, can also be used as matrix materials, possibly also pyrroles, imidazoles, triazoles, pyridines, pyrimidines, pyridazines, and the like. The heteroaromatic compounds are preferably substituted, in particular aryl-substituted, such as phenyl or naphthyl-substituted.” *Id.*, 55:8–12. It is my opinion that all of these matrix materials are organic compounds.

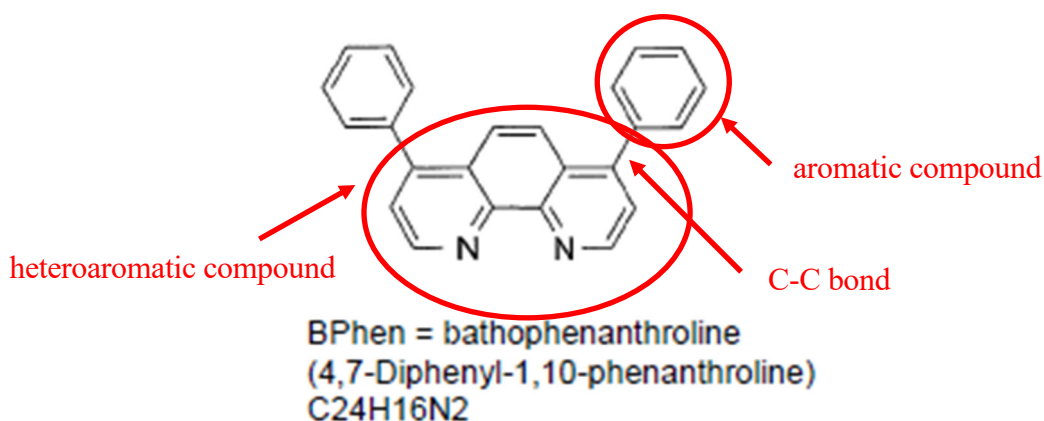
70. **Fourth**, it is my opinion that Werner discloses that *the electron-conducting layer is obtained by joint vaporization of a metal complex with an organic compound* because “[t]he provided metal complex is evaporated simultaneously with the matrix material” to form an n-doped organic semiconductor layer. Werner, 61:10–11.

- d) **Element 1[c]: wherein the organic compound comprises a heteroaromatic compound which is conjugated with an aromatic compound via a C—C bond.**

71. It is my opinion that Werner discloses this element. Two of the matrix materials disclosed by Werner, BPhen, and 3-(4-biphenyl)-4-phenyl-5-tert-

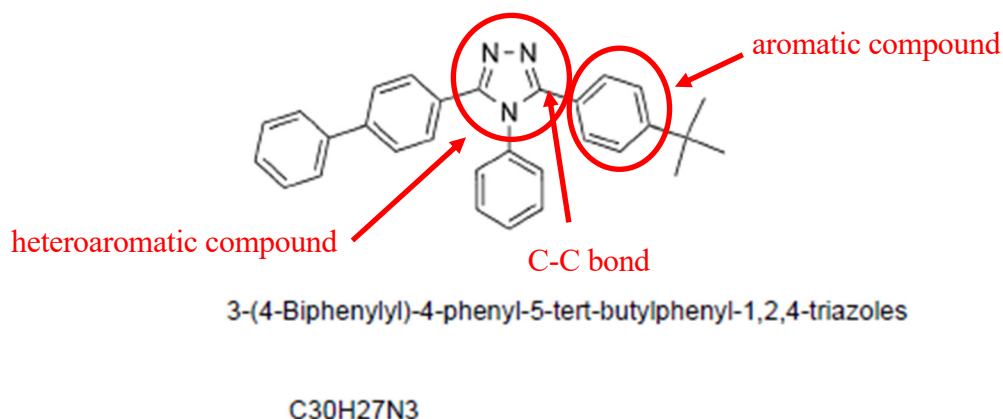
butylphenyl-1,2,4-triazole (C₃₀H₂₇N₃) are discussed above. *See supra* Section VIII.A.1.c.

72. The structure of BPhen is shown below:



Id., 54:11–13 (annotated). It is my opinion that BPhen is a heteroaromatic compound conjugated with an aromatic compound via a C—C bond, as shown above. It is also my opinion that BPhen is Compound VI in claim 6, and it is recited in claim 6’s list of organic compounds that may serve as the “organic compound [that] comprises a heteroaromatic compound which is conjugated with an aromatic compound via a C—C bond” of claim 1.

73. The structure of 3-(4-biphenyl)-4-phenyl-5-tert-butylphenyl-1,2,4-triazole (C₃₀H₂₇N₃) is shown below:



Werner, 55:15–17 (annotated). It is my opinion that this compound is also a heteroaromatic compound conjugated with an aromatic compound via a C—C bond, as shown above.

2. Dependent Claim 2: The organic electronic component according to claim 1, wherein the organic compound coordinates to the metal complex due to the joint vaporization.

74. It is my opinion that as discussed in Section VIII.A.1, claim 1 is disclosed in Werner. Werner discloses the additional elements in claim 2.

75. **First**, it is my opinion that Werner discloses a metal complex that can coordinate to an organic compound. For example, Werner discloses W₂(hpp)₄ as one of the examples of the “electron-rich neutral metal complex” for the n-doped organic semiconductor layer. Werner, 60:17–21 (“M₂hpp₄ with M equals Cr, Mn, Fe, Co, Ni, Cu, Zn, Mo, or *W*”) (emphasis added); *see also* 13:16–21 (“Preferably, at least one ligand, two, several, or all ligands are selected from the group of halides, carboxylates, formamidinates, pyrimido-pyrimidines including their anions, in particular substituted

or unsubstituted pyrimido [1,2-a]pyrimidine or their anions, *in particular hpp (hpp: anion of 1,3,4,6,7,8-hexahydro-2H-pyrimido[1,2-a]pyrimidine)*” (emphasis added).

It is my opinion that $W_2(hpp)_4$ has two central metal atoms (tungsten) and the ability to coordinate with an organic compound. The '223 patent confirms that for a metal complex for an electron conducting layer, “W is a preferred central metal atom” due to “the ability to coordinate with additional ligands [i.e., organic compounds]” and that “[i]t is particularly preferred if all of the central atoms in the metal complex are W.” '223 patent, 3:4–8.

76. **Second**, it is my opinion that Werner discloses an organic compound that can coordinate to a metal complex. For example, Werner discloses that “[i]n particular, BPhen can be used as the matrix material.” Werner, 55:5–6. Indeed, as of 2009, BPhen had been used as a matrix material in organic electronic components. BPhen also contains two nitrogens, which, in certain circumstances, can serve as a site for chemical interactions with other molecules, like metal complexes, for example. The '223 patent confirms that BPhen (Compound VI) is one of the compounds that “are particularly well suited as an organic compound for the electron-conducting layer” because it “comprises several coordination sites for metal complexes.” '223 patent, 7:43–48; *see also id.* 7:47–63 (“These compounds I-XIII . . . have large delocalized electron systems [which] . . . enable the compounds to accept and transport further negative charges very effectively since this additional charge can be easily distributed onto several

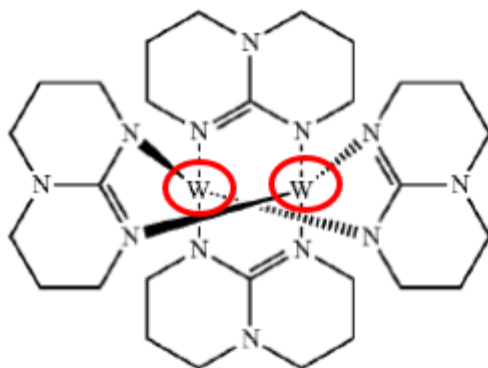
atoms in the molecule. Therefore, a coordinated metal complex can effectively transfer a negative charge to the organic compound coordinated thereto.”).

77. **Third**, it is my opinion that Werner discloses that “the metal complex is evaporated simultaneously with the matrix material” to form an n-doped organic semiconductor layer. Werner, 61:10–11. The ’223 patent discloses that “[b]y virtue of the joint vaporization of the metal complex with an organic compound, the two compounds interact with one another in the gas phase or when they meet one another on the substrate surface” ’223 patent, 1:60–63. It is my opinion that because $W_2(hpp)_4$ and BPhen are the materials that can coordinate when jointly vaporized according to the ’223 patent, Werner discloses that *the organic compound coordinates to the metal complex due to the joint vaporization*.

3. Dependent Claim 3: The organic electronic component according to claim 1, wherein the metal complex comprises more than one central metal atom.

78. It is my opinion that as discussed in Section VIII.A.1, claim 1 is disclosed in Werner. Werner discloses the additional elements in claim 3.

79. As discussed in Section VIII.A.1.c, Werner discloses $W_2(hpp)_4$ as a metal complex that can be used for the n-doped organic semiconductor layer. Werner, 60:20–21. It is my opinion that $W_2(hpp)_4$ comprises more than one central metal atom (designated by the red circles in the figure below, using the structure from the ’223 patent).



'223 patent, 3:21–45 (describing $W_2(TBD-A)_4$ (i.e., $W_2(hpp)_4$) as a metal complex of which “many electrons can be donated by the *two central W-atoms*”) (emphasis added).

4. Dependent Claim 4: The organic electronic component according to claim 1, wherein the central metal atom or central metal atoms is/are selected from Cr, Mo or W.

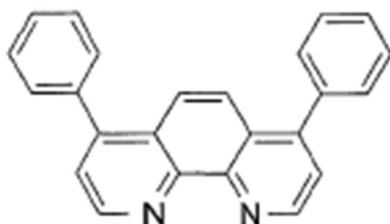
80. It is my opinion that as discussed in Section VIII.A.1, claim 1 is disclosed in Werner. Werner discloses the additional elements in claim 4.

81. As discussed in Section VIII.A.3, Werner discloses $W_2(hpp)_4$ as a metal complex that can be used for the n-doped organic semiconductor layer. Werner, 40:59–64. It is my opinion that $W_2(hpp)_4$ comprises two W atoms as central metal atoms, which is further confirmed by the '223 patent. '223 patent, 3:21–45.

5. Dependent Claim 6: The organic electronic component according to claim 1, wherein the organic compound is selected from [Compounds I–XIII].

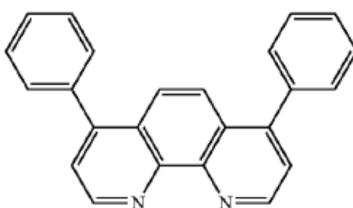
82. It is my opinion that as discussed in Section VIII.A.1, claim 1 is disclosed in Werner. Werner discloses the additional elements in claim 6.

83. As discussed in Section VIII.A.1.c, Werner discloses BPhen as the preferred matrix material (organic compound) that can be used for the n-doped organic semiconductor layer. BPhen is Compound VI specified in claim 6 of the '223 patent. The structures of BPhen from Werner and Compound VI in the '223 patent are shown below, and are identical:



BPhen = bathophenanthroline
(4,7-Diphenyl-1,10-phenanthroline)
C₂₄H₁₆N₂

Werner, 54:11–13.



VI

'223 patent, col. 6.

- 6. Dependent Claim 8: The organic electronic component according to claim 1, wherein at least parts of the organic compounds bridge two metal complexes together, so that a chain-like structure of the metal complexes is formed and/or at least parts of the organic compounds bridge more than two metal complexes together, so that a network-like structure of the metal complexes is formed.**

84. It is my opinion that as discussed in Section VIII.A.1, claim 1 is disclosed in Werner. In my opinion, Werner discloses and/or renders obvious the additional elements in claim 8.

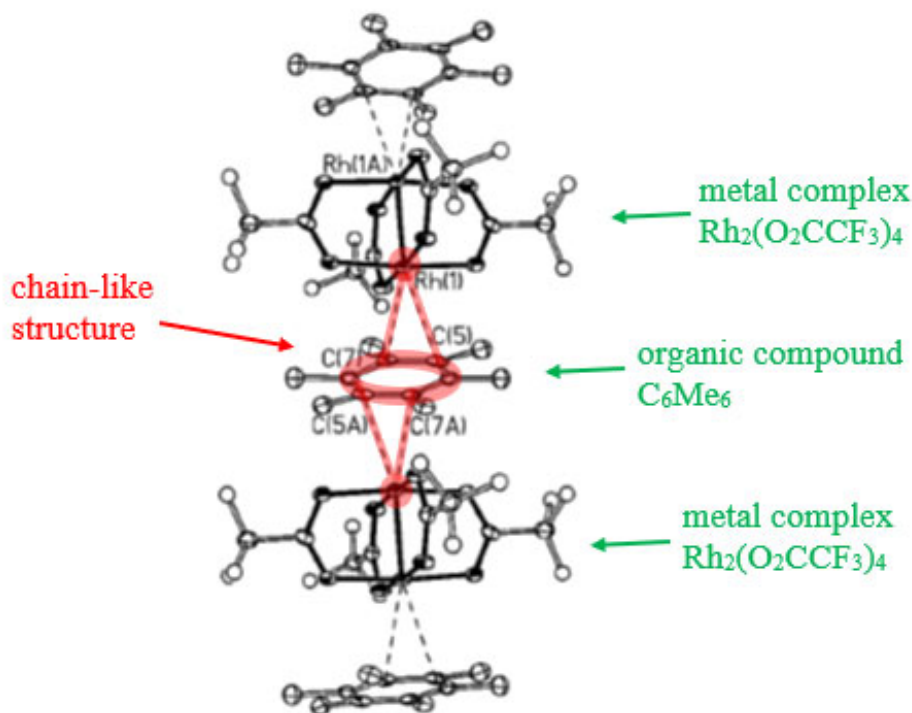
85. Werner discloses a metal complex with two central atoms ($W_2(hpp)_4$), an organic compound (BPhen), and manufacturing processes that the '223 patent purports would achieve the additional elements in claim 8. The '223 patent discloses that “[b]y virtue of the joint vaporization of the metal complex with an organic compound, the two compounds interact with one another in the gas phase or when they meet one another on the substrate surface” ’223 patent, 1:60–62; *see also id.*, 11:17–29.

86. Although Werner does not expressly disclose the structure formed by the metal complex and organic compound (matrix material) upon vaporization (evaporation), Werner discloses a metal complex ($W_2(hpp)_4$), organic compound (BPhen) and vaporization process, that would allow for formation of chain-like or network like structures, wherein at least parts of the organic compounds bridge two (or more) metal complexes together. In my opinion, using the same metal complex ($W_2(hpp)_4$), organic compound (BPhen) and vaporization process as in Werner, the

'223 patent describes such a combination as forming chain-like or network like structures, wherein at least parts of the organic compounds bridge two (or more) metal complexes together. *See, e.g.*, '223 patent, 1:60–62, 7:48–67, 11:17–26. I address each portion separately below.

a) The Metal Complex

87. Werner discloses a metal complex with two central atoms ($W_2(hpp)_4$). Werner, 60:20–21. The '223 patent discloses that “[m]etal complexes having two central atoms are particularly well suited for the formation of *chains*.” '223 patent, 2:49–50 (emphasis added) (citing F. Albert Cotton et al., 18 *Organometallics*, 2724–2726 (1999) (Ex.1012 and “Cotton 1999”)). The '223 patent explains that Cotton 1999 illustrates “[a] chain-like sequence of metal complexes and of *aromatic compounds bridging two adjacent complexes*.” '223 patent, 2:53–55 (emphasis added). Cotton 1999 provides the following image below:



Cotton 1999, Fig. 1 (annotated). The '223 patent explains that according to Cotton 1999, "the coordination of the aromatic system can lead to a chain formation, wherein two metal complexes are linked by an organic compound." '223 patent, 2:34–36. I observe that all the exemplary embodiments in the '223 patent used a metal complex having two central metal atoms, i.e., W₂(TBD-A)₄. (i.e., W₂(hpp)₄). '223 patent, 14:22–46, 16:61–18:45, Figs. 5–8. Like the Rh₂(O₂CCF₃)₄ in Cotton 1999, W₂(TBD-A)₄ (i.e., W₂(hpp)₄) which contains two central metal atoms, can be bridged by an organic compound *so that a chain-like structure of the metal complexes is formed*.

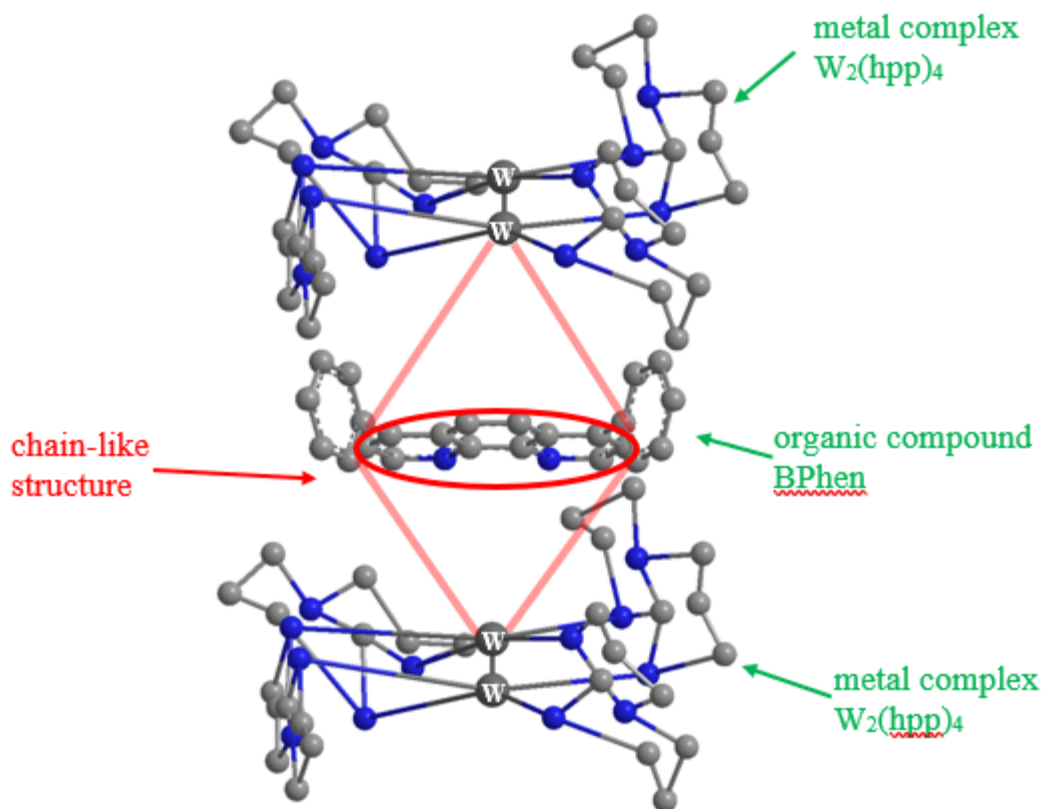
b) Organic Compound

88. Werner discloses BPhen, (Werner, 55:3–6) which is compound VI in the '223 patent.

89. The '223 patent discloses that “[t]he coordination of the organic compound to the central atom can be effected directly via a further atom or else also via an aromatic system.” ’223 patent, 2:19–21. BPhen can coordinate to metal complexes because it has both an aromatic compound and also a nitrogen heterocycle. Further, BPhen has a heteroaromatic group, whose delocalized electron system also enables coordination to metal complexes. Indeed, the ’223 patent confirms that “each of [Compounds I to XIII disclosed in the ’223 patent, which includes BPhen] comprises both an aromatic compound and also a nitrogen heterocycle” and “thus comprises several coordination sites for metal complexes.” ’223 patent, 7:45–48. The ’223 patent also confirms that “[f]urthermore, these compounds [I-XIII] have large delocalized electron systems, such as for example condensed aromatic compounds or aromatic compounds which are in electronic conjugation with each other.” ’223 patent, 7:53–57. The ’223 patent explains that “[i]n contrast to an aromatic compound, a heteroaromatic compound has the advantage that it is not only able to coordinate to a metal complex via the aromatic system (π -electrons), as described in the [Cotton 1999], but furthermore the coordination can also be effected directly via the heteroatom.” ’223 patent, 3:56–61. In other words, it is my opinion that the ’223 patent contends that heteroaromatic compounds with heteroatoms (like BPhen) coordinate to metal complexes (like $W_2(hpp)_4$) via two different mechanisms: with delocalized π electrons and with the heteroatoms.

90. It is my opinion that BPhen can form two-dimensional chains or three-dimensional networks. The '223 patent confirms that “[t]hese compounds I to XIII [including Compound VI, BPhen] allow not only for the formation of two-dimensional *chains*, but, by virtue of their multiplicity of coordination sites, they also allow for the formation of three-dimensional *networks*.” ’223 patent, 7:48–51 (emphasis added).

91. It is my opinion that the heteroaromatic portion of the compound of BPhen is planar, like the benzene ring in C_6Me_6 from Cotton 1999. $W_2(hpp)_4$ has a similar structure to $Rh_2(O_2CCF_3)_4$, in that it contains two transition metal atoms (W vs. Rh) and four organic ligands. Thus, in my opinion, a POSA would have expected that, similar to Fig. 1 of Cotton 1999, BPhen can *bridge two $W_2(hpp)_4$ molecules together, so that a chain-like structure of the metal complexes is formed*, as I illustrated below:



c) Vaporization Process

92. Werner discloses a method of jointly depositing $W_2(hpp)_4$ and BPhen in a manner that would allow for coordination.

93. It is my opinion that simultaneous (or joint) vaporization of the metal complex $W_2(hpp)_4$ and the organic compound BPhen can result in coordination and the formation of chain- or network-like structures. The '223 patent contends that this coordination and formation takes place. *See, e.g., '223 patent, 11:17–26* (discussing how “joint vaporization” of binuclear metal complexes and “one of the compounds of I-XIII” leads to “coordination” and “can result in the formation of two-dimensional

chains or three-dimensional networks.”). Thus, the metal complex $W_2(hpp)_4$, one of the preferred metal complexes of the '223 patent, and disclosed by Werner (Werner, 60:20–21) and the organic compound BPhen, one of the preferred organic compounds (compound VI) of the '223 patent, and disclosed by Werner (Werner, 55:3–6), according to the '223 patent, can coordinate via joint vaporization to form *chain-like or network-like structures*.

94. Werner discloses manufacturing processes that result in simultaneous (or joint) vaporization of $W_2(hpp)_4$ and BPhen, which would allow coordination of a metal complex and an organic compound, wherein *at least parts of the organic compounds bridge two metal complexes together, so that a chain-like structure of the metal complexes is formed*. For example, Werner discloses that “[t]he doping of the respective matrix material with the n-dopants according to the invention can be carried out by one or a combination of the following methods” and discloses five different processes. Werner, 56:13–30. One disclosed method (Method (a)) is “[c]o-evaporation in a vacuum with one source for the matrix material and one for the dopant[.]” Werner, 56:17–18. It is my opinion that this is the same process later disclosed in the '223 patent. '223 patent, 14:11–17.

95. It is my opinion that use of this method, which would jointly vaporize $W_2(hpp)_4$ and BPhen, would result in coordination of $W_2(hpp)_4$ and BPhen, wherein *at least parts of the organic compounds (BPhen) bridge two metal complexes ($W_2(hpp)_4$)*

together, so that a chain-like structure of the metal complexes is formed. For this reason alone, Werner discloses this limitation.

d) Coordination in the Gas Phase

96. It is my opinion that to the extent that forming a chain-like structure of the metal complexes wherein at least parts of the organic compounds bridge two metal complexes together is dependent on joint vaporization and coordination of $W_2(hpp)_4$ and BPhen *in the gas phase*, Werner also discloses this limitation.

97. Werner discloses methods of depositing $W_2(hpp)_4$ and BPhen in a manner that would allow for coordination in the gas phase. As described by the '223 patent, the formation of chain-like or network-like structures arises “[b]ecause of the coordination of the organic compound to the metal complex in the gas phase” ’223 patent, 13:51–53.

98. The '223 patent describes that joint vaporization leads to the coordination of a metal complex and organic compound in the gas phase. The '223 patent provides that “[b]ecause of the simultaneous vaporization of metal complexes and organic compounds, both compounds are simultaneously present next to each other in the gas phase. This enables the organic compound to coordinate to the metal complex in the gas phase.” ’223 patent, 13:36–40; *see also* ’223 patent, 13:29–33 (“Deposition of the electron-conducting layer can be effected by means of simultaneous vaporization of a metal complex and an organic compound. The simultaneous vaporization enables the

molecules to interact with each other.”).

99. According to the '223 patent, simultaneous (or joint) vaporization of $W_2(hpp)_4$ and BPhen results in coordination, and “[b]ecause of the coordination of the organic compound to the metal complex in the gas phase, chain-like or network-like structures can be formed.” ’223 patent, 13:51–53 (emphasis added). Thus, in my opinion, as confirmed by the ’223 patent, $W_2(hpp)_4$, one of the preferred metal complexes of the ’223 patent and disclosed by Werner (Werner, 60:20–21), and BPhen, one of the preferred organic compounds (compound VI) of the ’223 patent and disclosed by Werner (Werner, 55:3–6), would necessarily coordinate in the gas phase to form *chain-like or network-like structures*.

100. As I discussed above, Werner discloses manufacturing processes that result in simultaneous (or joint) vaporization of the metal complex ($W_2(hpp)_4$) and matrix material (BPhen), that, according to the ’223 patent, would allow coordination of a metal complex and an organic compound in the gas phase, wherein *at least parts of the organic compounds bridge two metal complexes together, so that a chain-like structure of the metal complexes is formed*. *Supra* Section VIII.A.6.c.

101. Werner discloses that “[t]he doping of the respective matrix material with the n-dopants according to the invention can be carried out by one or a combination of the following methods” and discloses five different processes. Werner, 56:13–30. One disclosed method (Method (a)) is “[c]o-evaporation in a vacuum with one source for

the matrix material and one for the dopant.” Werner, 56:17–18. This is the same method later disclosed in the ’223 patent. ’223 patent, 14:11–46. According to the ’223 patent, use of this method with $W_2(hpp)_4$ and BPhen would result in coordination of $W_2(hpp)_4$ and BPhen in the gas phase wherein *at least parts of the organic compounds (BPhen) bridge two (or more) metal complexes ($W_2(hpp)_4$) together, so that a chain-like or network-like structure of the metal complexes is formed*. It is my opinion that for this reason alone, Werner discloses this limitation.

102. In the alternative, a POSA would have been motivated to combine Methods (a) and (e) (Werner, 56:26–30 (“[p]reparation of a solution of matrix molecules and dopants and subsequent formation of a layer from this solution by conventional methods[,] such as solvent evaporation or spin-coating.”)) in Werner to prepare a mixture of matrix material and dopant (Method (e)) and vaporize the mixture in a vacuum (Method (a)), because Werner teaches that “a combination” of Methods (a) and (e) are appropriate. Werner, 56:13–30. In my opinion, doing so would allow for $W_2(hpp)_4$ and BPhen to be in close proximity in the gas phase, so as to present an opportunity for BPhen to bridge two (or more) $W_2(hpp)_4$ molecules, such that a chain-like or network-like structure is formed.

103. In a second alternative, it is my opinion that a POSA would have been motivated to evaporate a mixture of BPhen and $W_2(hpp)_4$ from a single crucible under vacuum. In my opinion, when $W_2(hpp)_4$ and BPhen are pre-mixed before evaporation

and evaporated from a single crucible in a vacuum, both compounds are likely to simultaneously present next to each other in the gas phase and there is an opportunity for $W_2(hpp)_4$ and BPhen molecules to interact and coordinate in the gas phase due to the proximity of these molecules.

104. In my opinion, a POSA, seeking to control the evaporation rate more finely, would have known that evaporation of a mixture of BPhen and $W_2(hpp)_4$ from a single crucible under vacuum would have advantages over evaporation from two separate crucibles.

105. This knowledge is confirmed by a second Werner application, US Patent Publication 2007/0249148 (“Werner II”), which serves as an illustration of the background knowledge of a POSA. Werner II is directed to doped semiconductor material on a substrate, naming overlapping inventors as Werner, and assigned to the same company Novald AG, which describes shortcomings of the vacuum vaporization of a matrix material and doping material from two separate crucibles and provides evidence of the knowledge a POSA would have to vaporize BPhen and $W_2(hpp)_4$ from a single crucible:

This method has a number of drawbacks. It is necessary for the evaporation rates of the evaporation sources to be controlled very accurately throughout the entire evaporation process in order to achieve homogeneous doping. Furthermore, the radiation emission characteristics and the arrangement of the evaporation sources have to be such that the

ratio of the flow rates of matrix material and dopant is constant over the entire surface of the substrate. This can only be ensured with considerable difficulty in particular for substrates with a large base area. Furthermore, it is necessary to provide an additional evaporator for the dopant for each doped layer when designing an evaporation installation. Not least, the maintenance outlay for an installation of this type is increased considerably. Finally, there is a considerably increased outlay on control engineering for operation of the evaporators.

Werner II, [0010]. Specifically, Werner II describes that “in particular producing devices with organic layers, such as organic light-emitting diodes,” a matrix material and a dopant can be “sublimed/vaporized from the same vaporization source.” *Id.*, [0016]. Werner II explains that “[t]he proposed method simplifies the production of doped layers. The properties of the molecular flows of matrix material and dopant can be identically configured, since both materials are sublimed/vaporized from the same vaporization source.” *Id.*, [0015]–[0016]. Werner II specifically describes that “a mixture of the at least one semiconductor matrix material and the at least one doping material is converted into a vapour phase with the aid of a vaporization source and then deposited on the substrate” and that “[i]t is possible to use mixtures of two or more materials.” *Id.*, [0015]. In my opinion, the common inventor in Werner and Werner II demonstrates that they relate to continued work in a common field of effort and continued related developments in that field, and thus would reflect the knowledge held by the POSA to have been motivated to combine Methods (a) and (e) of Werner,

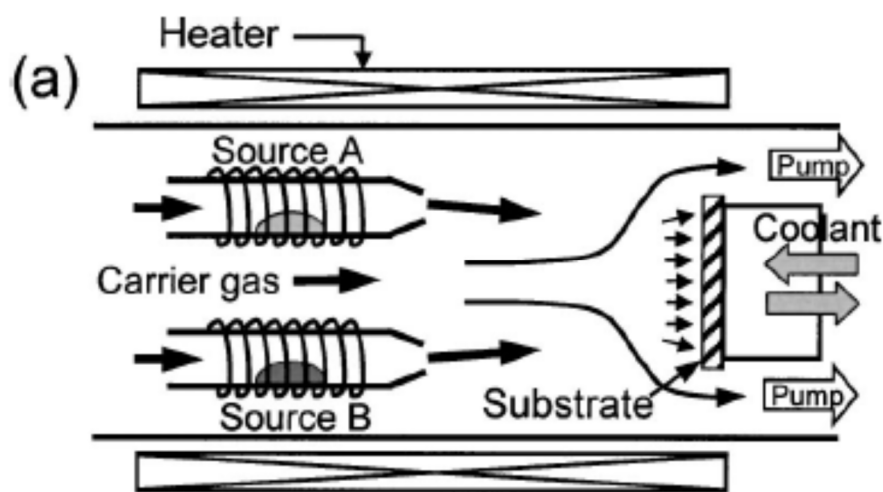
to give a metal complex and organic compound that coordinate in the gas phase, wherein *at least parts of the organic compounds bridge two metal complexes together, so that a chain-like structure of the metal complexes is formed.*

106. In a third alternative, it is my opinion that a POSA would have been motivated to modify the parameters of deposition to achieve coordination of BPhen and $W_2(hpp)_4$ in the gas phase. In my opinion, a POSA would have understood that if the BPhen and $W_2(hpp)_4$ coordinate in the gas phase, the complex which is deposited will be coordinated BPhen and $W_2(hpp)_4$. A POSA would also have understood that a deposited layer of coordinated BPhen and $W_2(hpp)_4$ will contain a more uniform distribution of BPhen and $W_2(hpp)_4$, than if the BPhen and $W_2(hpp)_4$ were individually deposited such that coordination happens on the surface. It is my opinion that a POSA would have understood that a more uniform layer of coordinated BPhen and $W_2(hpp)_4$ would allow for the more efficient transfer of electrons through that layer. Additionally, a POSA would also have understood that a more uniform layer of coordinated BPhen and $W_2(hpp)_4$ would also allow for the more efficient use of materials to make the electron conducting layer.

107. In my opinion, one way a POSA could have increased the likelihood of coordination of BPhen and $W_2(hpp)_4$ in the gas phase is through choosing a method of deposition that ensures a low vacuum in the reaction chamber. In my opinion, using a low vacuum in the reacting chamber would increase collision of the vaporized BPhen

and $W_2(hpp)_4$ molecules in the gas phase rather than on the substrate. Thus, it is my opinion that a POSA would have been motivated to execute the co-evaporation of BPhen and $W_2(hpp)_4$ under a low vacuum, for example, a 0.1–10 Torr to employ the organic vapor phase deposition (OVPD) method, as evidence by the knowledge of a POSA, as shown by Shtein (Ex.1008).

108. Shtein is directed to organic-based electronic devices such as organic light emitting diodes (OLEDs) formed by organic vapor phase deposition (OVPD). Shtein, 4005. Shtein discloses that “the technique of organic vapor phase deposition (OVPD) was introduced as an alternative to VTE [vacuum thermal evaporation] growth of small-molecular weight organic thin films, heterostructures, and devices” and that “[i]n OVPD, a hot, nonreactive carrier gas is used to transport an organic vapor toward a cooled substrate onto which the organic materials condense, as shown in Fig. 1(a).” Shtein, 4006. Fig. 1(a) of Shtein is reproduced below:



Shtein, 4006, Fig. 1(a).

109. Shtein explains that the advantages of OVPD is that it “affords precise control over the layer thickness and dopant concentration, while increasing the materials use efficiency over that obtained by VTE.” Shtein, 4006. In my opinion, these advantages align with a POSA’s motivation to achieve coordinated BPhen and $W_2(hpp)_4$ in the gas phase. Shtein teaches that “[i]n contrast to the conventional process of vacuum thermal evaporation, the background has pressure during OVPD is typically 0.1–10 Torr.” *Id.*, 4005, Abstract. Thus, it is my opinion that a POSA would have been motivated to use a 0.1–10 Torr vacuum for the co-evaporation method in Werner in view of Shtein.

110. In my opinion, applying the method of Shtein method would increase collision of the vaporized $W_2(hpp)_4$ and BPhen molecules so that there would be a higher opportunity for BPhen to coordinate in the gas phase to $W_2(hpp)_4$ rather than on the substrate, thereby achieving a POSA’s goal of coordination in the gas phase. It is my opinion that according to the ’223 patent, coordination in the gas phase of metal complexes such as $W_2(hpp)_4$ to organic compounds like BPhen would allow for at least parts of the organic compounds bridge two (or more) metal complexes together, so that a chain-like (or network-like) structure of the metal complexes is formed.

e) Embodiments in the ’223 Patent Confirm a POSA’s Reasonable Expectation of Success

111. In my opinion, a POSA would have understood that the metal complex ($W_2(hpp)_4$), organic compound (BPhen) and vaporization process of Werner would

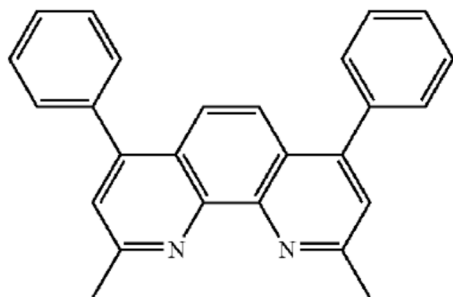
successfully allow for coordination, and therefore, formation of *chain-like or network-like structures*, wherein *at least parts of the organic compounds bridge two (or more) metal complexes together*. This is confirmed by the examples in the '223 patent.

112. The '223 patent discloses an embodiment in which three-dimensional *network* of a metal complex and an organic compound was purportedly formed, using simultaneous vaporization from two separate crucibles. The '223 patent discloses that “[t]he electron-conducting layer has a *three-dimensional network* of the metal complex $W_2(TBD-A)_4$ and the organic compound I” when “[i]n a vacuum recipient, an electrically heatable silica or ceramic crucible is charged with 200 mg of $W_2(TBD-A)_4$ ” and “a further silica or ceramic crucible is charged with the organic compound of above-mentioned structure I” and “two sources are regulated to a deposition rate of 4.5 nm/s” during vaporization. '223 patent, 14:22–34 (emphasis added).

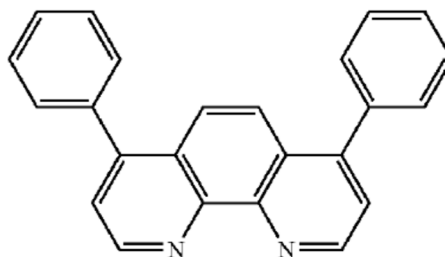
113. Werner discloses an identical process condition as in this embodiment. Werner discloses that “[t]he doping of the respective matrix material with the n-dopants according to the invention can be carried out by . . . [c]o-evaporation in a vacuum with a source for the matrix material and one for the dopant” Werner, 56:13–18. In my opinion, because Werner discloses the same manufacturing process as the embodiment of the '223 patent that purportedly enabled a network structure with $W_2(TBD-A)_4$ and one of the organic compounds that was specifically recommended by the '223 patent for a chain-like or network-like structure (*see* '223 patent, 7:48–51),

a POSA would have understood that joint evaporation of $W_2(hpp)_4$ and BPhen (Compound VI of the '223 patent) according to the method set out in Werner would also form a *three-dimensional network* as in the embodiment of the '223 patent. Alternatively, for the same reasons, a POSA would have found it highly likely that that joint evaporation of $W_2(hpp)_4$ and BPhen (Compound VI of the '223 patent) according to the method set out in Werner would also form a *three dimensional network* as in the embodiment of the '223 patent.

114. Further, the '223 patent specifically discloses examples “according to the invention” in which Compound V was co-deposited with $W_2(TBD-A)_4$. '223 patent, 16:56–17:21. In my opinion, Compound V and Compound VI are structurally very similar, differing only by two methyl groups on Compound V. Both Compound V and Compound VI have multiple heteroatoms and planar aromatic structures that have delocalized π electrons. The structures of these two compounds are shown below:



Compound V (BCP)



Compound VI (BPhen)

115. In my opinion, given the structural similarities between Compound V (BCP) and Compound VI (BPhen), if Compound V and $W_2(TBD-A)_4$ (i.e., $W_2(hpp)_4$)

achieve the claimed invention when simultaneously vaporized, a POSA would have understood that Compound VI (BPhen) would also achieve the claimed structure with $W_2(\text{TBD-A})_4$ (i.e., $W_2(\text{hpp})_4$). Alternatively, for the same reasons, a POSA would have found it highly likely that Compound VI (BPhen) would also achieve the claimed structure with $W_2(\text{TBD-A})_4$ (i.e., $W_2(\text{hpp})_4$). Thus, it is my opinion that to the extent that Compound V and $W_2(\text{TBD-A})_4$ (i.e., $W_2(\text{hpp})_4$) achieved a chain-like or network-like structure, Compound VI (BPhen) and $W_2(\text{TBD-A})_4$ (i.e., $W_2(\text{hpp})_4$) would also achieve such a chain-like or network-like structure.

7. Dependent Claim 9: The organic electronic component according to claim 1, which is formed as an organic LED (OLED) which additionally comprises an organic emitting layer.

116. It is my opinion that as discussed in Section VIII.A.1, claim 1 is disclosed in Werner. Werner discloses the additional elements in claim 9.

117. Werner discloses that “[a]fter applying the n-doped organic semiconductor layer according to the invention, a metal cathode is applied, for example, by vapor deposition of a suitable metal to produce an *organic light-emitting diode*” (Werner, 61:19–22 (emphasis added)), and that “depending on the particular application, further layers may be provided between the individual layers mentioned.” Thus, it is my opinion that although an *organic emitting layer* is not explicitly disclosed in Werner, the organic light-emitting diode by definition would inherently comprise an organic emitting layer.

8. Independent Claim 10

- a) Preamble: A method for manufacturing an organic electronic component, comprising the method steps of:**

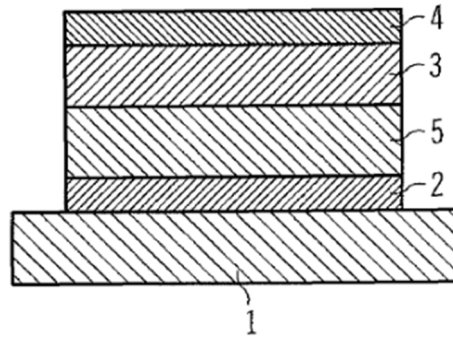
118. I have been informed that the preamble to a claim may or may not be viewed to be a limitation (or element) to the claim. To the extent the preamble is limiting, Werner discloses it. *Supra* Section VIII.A.1.a.

- b) Element 10[a]: A) providing a substrate, B) applying a first electrode, C) depositing an electron-conducting layer on the substrate, D) applying a second electrode,**

119. Werner discloses this element. Werner discloses the steps of a) providing a substrate (i.e., a glass substrate), B) applying a first electrode (i.e., an ITO layer) and C) (“depositing an electron-conducting layer on the substrate”). Werner, 61:17–19 (“The layer of organic semiconductor material doped with the n-dopant according to the invention is applied to an ITO layer (indium tin oxide) arranged on a glass substrate.”).

120. As for the step C) (“depositing an electron-conducting layer on the substrate”), the ’223 patent uses the term “on” in reference to a layer that is formed above a substrate though not directly in contact with it. For example, although the second electrode 4 in Fig. 1 is not directly in contact with the substrate, the ’223 patent describes that the second electrode 4 is “on” the substrate 1. *See, e.g.,* ’223 patent, 15:14–15 (“FIG. 1 shows a layer sequence comprising a substrate 1, *on which* a first electrode 2 and *a second electrode 4* are arranged.”) (emphasis added).

FIG 1



'223 patent, Fig. 1. Thus, it is my opinion that in the context of the '223 patent, the n-doped organic semiconductor layer of Werner is deposited on the substrate although it is not directly deposited on the substrate.

121. Further, Werner discloses applying “a metal cathode” after the n-doped semiconductor layer is applied, as recited by step D). Werner, 61:19–22.

- c) **Element 10[b]: wherein the electron-conducting layer is deposited by means of simultaneous vaporization of a metal complex and an organic compound,**

122. Element 10[b] is identical to Element 1[b] except that Element 10[b] does not require that the metal complex comprise a central metal atom. Werner discloses Element 10[b] for the same reasons as Element 1[b]. *Supra* Section VIII.A.1.c.

- d) **Element 10[c]: wherein the organic compound comprises a heteroaromatic compound which is conjugated with an aromatic compound via a C—C bond.**

123. Element 10[c] is identical to Element 1[c]. Werner discloses Element 10[c] for the same reasons as Element 1[c]. *Supra* Section VIII.A.1.d.

9. Dependent Claim 11: The method according to claim 10, wherein during the simultaneous vaporization the organic compound coordinates in the gas phase to the metal complex.

124. It is my opinion that as discussed in Section VIII.A.8, claim 10 is disclosed in Werner. Werner discloses and/or renders obvious the additional elements in claim 11. *See supra* Section VIII.A.6.d.

10. Dependent Claim 12: The method according to claim 10, wherein the electron-conducting layer is deposited as a chain-like or network-like structure.

125. It is my opinion that as discussed in Section VIII.A.8, claim 10 is disclosed in Werner. Werner discloses and/or renders obvious the additional elements in claim 12, in that the BPhen and Liq would be deposited in a chain-like or network-like structure as discussed for claim 8. *See supra* Section VIII.A.6.

11. Dependent Claim 13: The method according to claim 12, wherein the degree of cross-linking of the electron-conducting layer is controlled by the ratio between the metal complex and the organic compound during vaporization.

126. It is my opinion that as discussed in Section VIII.A.10, claim 12 is disclosed in Werner. Werner discloses and/or renders obvious the additional elements in claim 13.

127. In the context of the '223 patent, a POSA would have understood that the degree of cross-linking in a layer is related to the electron conductivity of the layer because "[t]he formation of chain-like or network-like structures enables additional electrons to be able to be transferred from the metal complexes to the organic

compounds, said electrons are then available for charge transport in the electron-conducting layer.” (’223 patent, 11:29–33) and “[t]he degree of cross-linking and thus the formation of network-like or chain-like structures can be controlled by the ratio of metal complex to organic compound.” ’223 patent, 13:61–67.

128. Werner discloses that “[p]referably, the mentioned metal complexes are used according to the invention as n-dopants, e.g., in a ratio of $\leq 1:1$ or $\leq 1:2$.” Werner, 58:4–5. Werner also discloses that a doped layer can achieve a higher conductivity than an undoped layer. *Id.* 58:10–15 (“When using phthalocyanine zinc as the matrix, a conductivity of higher than 10^{-8} S/cm was obtained, for example 10^{-6} S/cm. . . . The conductivity of undoped phthalocyanine zinc, however, is at most 10^{-10} S/cm.”).

129. It was well-known to a POSA as of the priority date that the electron conductivity increases as the doping ratio of the metal complex to the organic compound increases up to a certain level, but that the electron conductivity decreases when the doping ratio is too high. *See, e.g.,* Ma (Ex.1007) at 812 (illustrating state of the art), Fig. 5. *See infra* Section VIII.B.9.

130. In my opinion, as of the priority date, a POSA would have been well aware that the degree of cross-linking is related to electron conductivity and that the ratio between the metal complex and the organic compound during vaporization affects the electron conductivity of the electron-conducting layer. Thus, a POSA would have reasonably expected that the degree of cross-linking of the electron-conducting layer

is controlled by the ratio between the metal complex and the organic compound during vaporization. Accordingly, it is my opinion that it would have been obvious that *the degree of cross-linking is controlled by the ratio between the metal complex and the organic compound during vaporization.*

12. Dependent Claim 14: The method according to claim 10, wherein the organic compound does not coordinate to the metal complex prior to vaporization.

131. It is my opinion that as discussed in Section VIII.A.8, claim 10 is disclosed in Werner. Werner discloses and/or renders obvious the additional elements in claim 14.

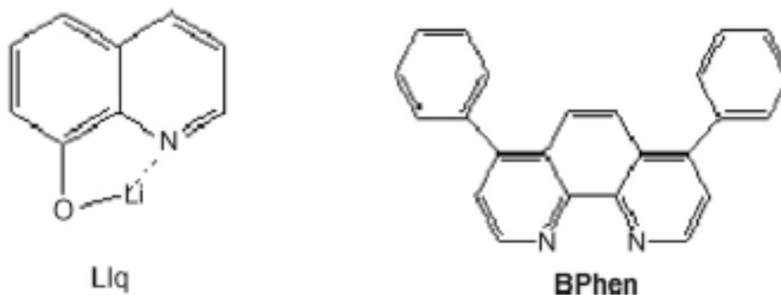
132. Werner discloses that “[t]he doping of the respective matrix material with the n-dopants according to the invention can be carried out by . . . (a) Co-evaporation in a vacuum with a source for the matrix material and one for the dopant.” Werner, 56:13–18. It is my opinion that because the matrix material (i.e., *organic compound*) and the dopant (i.e., *metal complex*) are contained in two separate sources prior to vaporization, there is no opportunity for the matrix material and the dopant to coordinate prior to vaporization.

B. Ground II: Claims 1–2, 6, and 8–14 Are Rendered Obvious by Ma

133. It is my opinion that Ma renders obvious all of the elements of claims 1–2, 6, and 8–14 of the ’223 patent, as discussed below. Further, it is my opinion that given the identical arrangement in Ma of each disclosed or suggested element, as

articulated in Ground II below, a POSA would have been motivated to arrive at the claims as a whole based on Ma's disclosure and a POSA's knowledge.

134. As discussed below, it is my opinion that Ma discloses an OLED structure including an anode, a cathode, and an electron transport layer. It is my opinion that the electron transport layer is electron-conducting and formed by joint vaporization of (i) a metal complex Liq as an n-dopant and (ii) BPhen as an organic compound. I have been informed that the Patent Owner has asserted that Liq is a metal complex which comprises a central metal atom (the metal atom Li), and I have been asked to assume this assertion is true. I have applied that assumption throughout my opinions. As discussed in Section VIII.A.1.d, BPhen comprises a heteroaromatic compound which is conjugated with an aromatic compound via a C—C bond.



Ma, 811, Fig. 1 (excerpted).

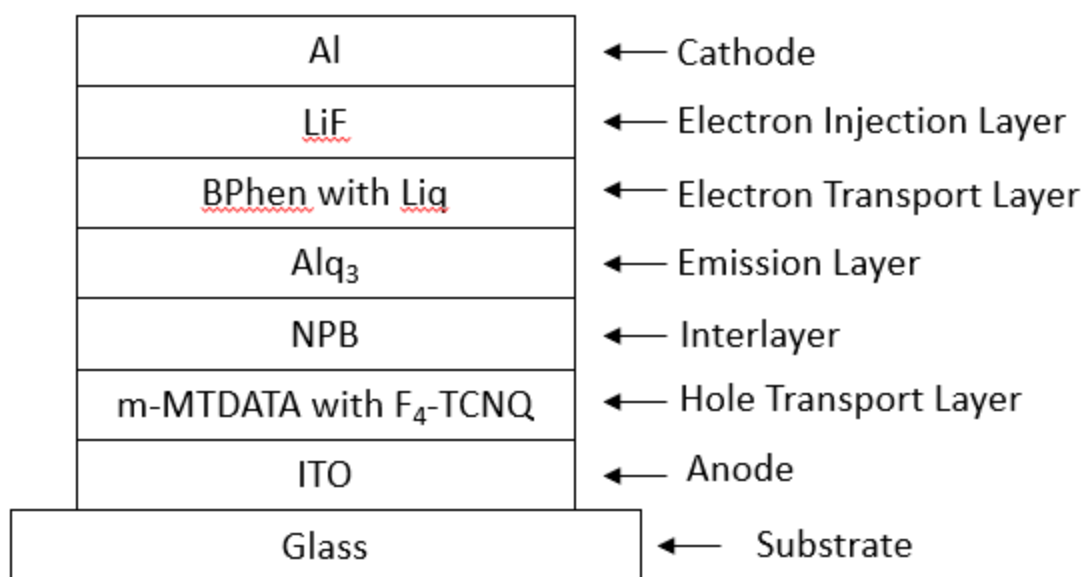
1. Independent Claim 1

a) Preamble: An organic electronic component, comprising:

135. It is my opinion that to the extent the preamble is limiting, Ma discloses it. Ma relates to “[o]rganic light-emitting diodes with 8-hydroxy-quinolinato lithium [Liq] doped 4’7-diphenyl-1, 10-phenanthroline [BPhen] as electron transport layer (ETL).” Ma, 811, Abstract. It is my opinion that because the organic light-emitting diode is an electronic device including an organic compound BPhen in the ETL, it is *an organic electronic component*.

b) Element 1[a]: a substrate, a first electrode, a second electrode, an electron-conducting layer which is arranged in such a way that it is electrically conductively connected to at least one of the electrodes,

136. It is my opinion that Ma discloses this element. Ma discloses that “[g]lass coated with ITO . . . was used as starting substrate.” Ma, 811. Ma discloses a hole transfer layer of “4,4’,4’’-tris(3-methylphenylphenylamono) triphenylamine (m-MTDATA):x wt.% [t]etraflu[o]ro-tetracyano-quinodimethane (F4-TCNQ),” and an electron transfer layer of BPhen and Liq. *Id.* The interlayer is formed using N,N’-diphenyl-N, N’-bis(1,1’-biphenyl)-4,4’-diamine (NPB) and the emission layer is formed using Alq₃, “while LiF and Al are used as electron injection layer and cathode, respectively.” Ma, 811. This structure is schematically shown below:



As shown above, in Ma, the *substrate* is glass, the anode is ITO (i.e., *a first electrode*), the electron transfer layer (ETL) (i.e., *an electron conducting layer*)⁴ is BPhen doped with Liq, and the cathode is Al (i.e., *a second electrode*). Ma, 811.

137. It is my opinion that because the “BPhen with Liq” layer (electron transport layer) is between the *first electrode* (ITO anode) and the *second electrode* (Al cathode), in order to produce a light-emitting diode, the electron-conducting layers would have to be *arranged in such a way that is electrically connected to at least one*

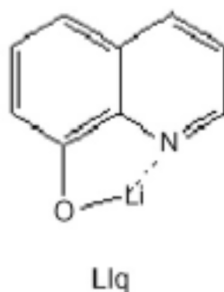
⁴ The '223 patent discloses that “the electron-conducting layer assumes the function of ... the electron-transporting layer.” '223 patent, 16:42–44. Thus, it is my opinion that the “BPhen with Liq” layer (electron transport layer) in Ma is an electron-conducting layer in the context of the '223 patent.

of the electrodes. It is also my opinion that because the electrode (Al) is deposited on the electron-injection layer (LiF), which in turn is deposited on the “BPhen with Liq” layer, the electron-conducting layer in Ma is arranged in such a way that it is electrically conductively connected to at least one of the electrodes.

- c) **Element 1[b]: wherein the electron-conducting layer is obtained by joint vaporization of a metal complex, which comprises a central metal atom, with an organic compound,**

138. It is my opinion that Ma discloses and/or renders obvious this element in view of the Patent Owner’s assertions regarding Liq.

139. **First**, Ma discloses Liq as the metal complex used in the ETL. Ma, 811. I understand that although ’223 patent is silent as to the meaning of the term “central” in this claim, Patent Owner has specifically identified Liq as a “metal complex” comprising Li as a “central metal atom.” It is my opinion that under Patent Owner’s interpretation, Ma discloses a metal complex which comprises a central metal atom. Liq comprises the metal atom of lithium (Li), as shown below.



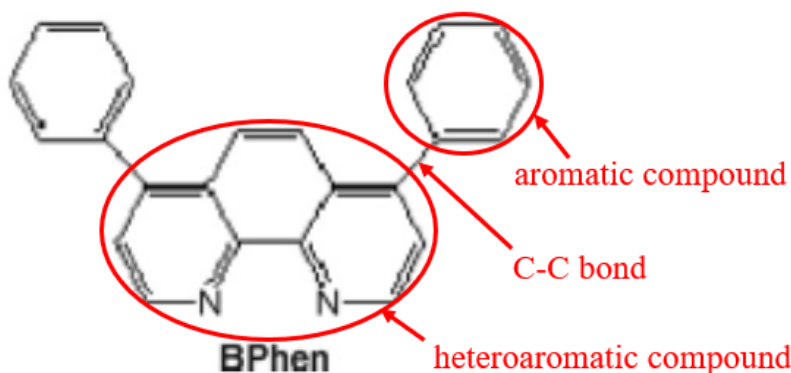
Ma, 811, Fig. 1 (excerpted).

140. **Second**, Ma discloses BPhen as the organic compound used in the ETL. Ma, 811, Fig. 1. As I discussed above, Section VIII.A.1.c, it is my opinion that BPhen, which is compound VI of the '223 patent, is an organic compound as used in the '223 patent.

141. **Third**, it is my opinion that Ma discloses that *the electron-conducting layer is obtained by joint vaporization of a metal complex with an organic compound* because the electron transport layer (ETL) was formed by joint vaporization of a metal complex (Liq) and an organic compound (BPhen). Ma, 811 (“a 50 nm-thick *BPhen:Liq ETL* was co-deposited on the EML. In the co-deposition process, organic sources were independently controlled. . . . *All the layers (organic layers, and Al electrode) of the devices were fabricated by conventional thermal evaporation* in a high vacuum chamber with a base pressure of 1×10^{-5} Torr.”) (emphasis added).

- d) **Element 1[c]: wherein the organic compound comprises a heteroaromatic compound which is conjugated with an aromatic compound via a C—C bond.**

142. Ma discloses this element. Ma discloses BPhen as the organic compound used for the electron transport layer. The structure of BPhen is shown below:



Ma, 811, Fig. 1 (excerpted and annotated). It is my opinion that BPhen is a heteroaromatic compound conjugated with an aromatic compound via a C—C bond, as shown above. BPhen is Compound VI of the '223 patent, which is claimed as a heteroaromatic compound conjugated with an aromatic compound via a C—C bond in the '223 patent. '223 patent, claims 1 and 6.

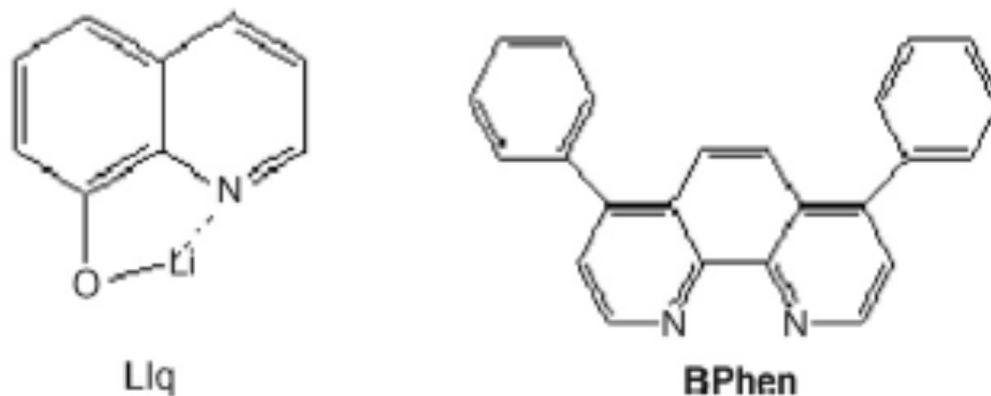
2. **Dependent Claim 2: The organic electronic component according to claim 1, wherein the organic compound coordinates to the metal complex due to the joint vaporization.**

143. It is my opinion that as discussed in Section VIII.B.1, claim 1 is disclosed in Ma. I have been informed that Patent Owner has asserted that the lithium in Liq will complex with at least some free electrons on nitrogen atoms in an organic compound

during joint vaporization. I have accepted and applied this assumption in rendering my opinions. Based on that assumption, it is my opinion that Ma discloses and/or renders obvious this element in claim 2.

144. As discussed above for claim 1, Ma discloses Liq and BPhen as the metal complex and the organic compound, respectively, used for the electron transport layer.

Ma, 810–11. The structures of Liq and BPhen are shown below:



Ma, 811, Fig. 1 (excerpted). Ma also discloses joint vaporization to create the ETL.

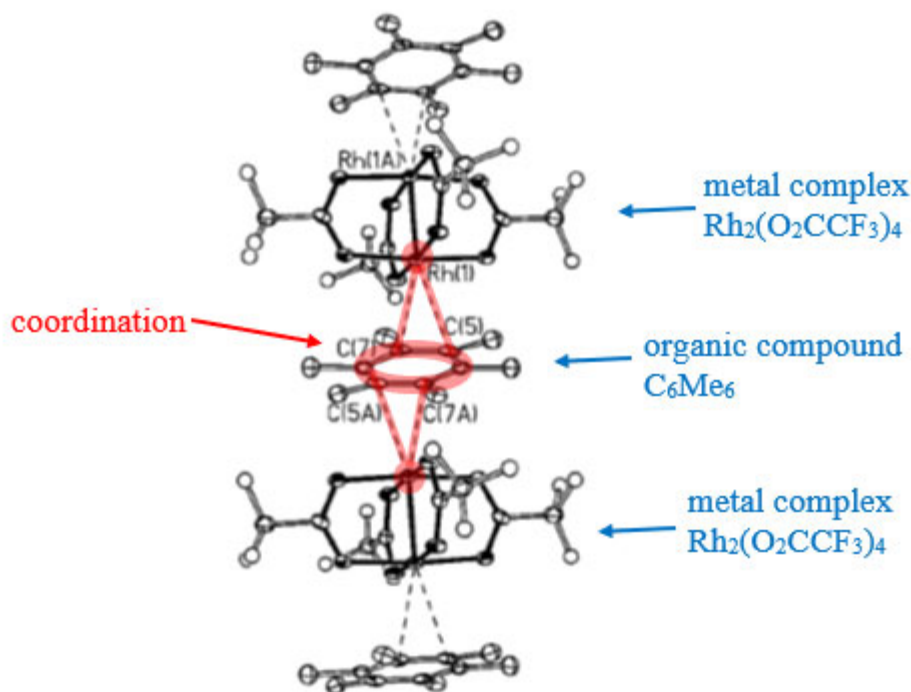
Ma, 811.

145. I understand that although the '223 patent does not specifically disclose Liq as one of the metal complexes that can coordinate to the organic compounds disclosed in the '223 patent due to joint vaporization, Patent Owner has specifically identified Liq as such a metal complex, contending that lithium coordinates with the free electrons on the heteroatoms of a heteroaromatic compound which is conjugated with an aromatic compound via a C—C bond, due to joint vaporization. It is my opinion that under Patent Owner's understanding, a POSA would have understood that

the lithium atom in Liq would similarly coordinate to the nitrogen atom(s) (or the delocalized π -electrons) of BPhen (one of the organic compounds specifically disclosed in the '223 patent, which “comprises several coordination sites for metal complexes” ('223 patent, 7:43–48)) due to joint vaporization.

146. I further observe that the '223 patent discloses that “[t]he coordination of the organic compound to the central atom can be effected directly via a further atom or else also via an aromatic system” ('223 patent, 2:19–21) and that “[b]y virtue of the coordination of the organic compound on the metal complexes, and the associated overlap of the orbitals, additional electrons can be transferred from the metal to the ligand via a metal complex-ligand-electron transfer (metal-ligand-charge-transfer complex)” *Id.*, 2:6–11. As discussed above with respect to Section VIII.A.1.c–d, BPhen comprises a heteroaromatic system which, according to the '223 patent, could coordinate to the electrons of Liq.

147. I understand that the '223 patent, relying on the Cotton 1999 reference, discloses a representative coordination between a metal complex and an organic compound, in which the Rh metal atoms of $\text{Rh}_2(\text{O}_2\text{CCF}_3)_4$ and the delocalized π electrons of the aromatic compound of C_6Me_6 form coordination, as illustrated below.



Cotton 1999, Fig. 1 (annotated). In my opinion, because BPhen has a planar central structure similar to C₆Me₆, along with additional heteroatoms with free electrons, and based on what I understand to be Patent Owner's contentions, a similar coordination between a BPhen molecule and two Liq molecules would occur.

148. In my opinion, Ma also discloses that any potential coordination of Liq and BPhen is due to the joint vaporization. In Ma, BPhen and Liq are jointly vaporized from two separate sources. Ma, 811 ("a 50 nm-thick *BPhen:Liq ETL* was co-deposited on the EML. In the co-deposition process, organic sources were independently controlled. . . . All the layers (organic layers, and Al electrode) of the devices were fabricated by conventional thermal evaporation in a high vacuum chamber with a base pressure of 1×10^{-5} Torr."). Ma, 811. Thus, in my opinion, any coordination between

Liq molecules and BPhen molecules could occur only after Liq and BPhen from the separate sources are jointly vaporized and interact with each other.

149. Thus, it is my opinion that Ma discloses an organic electronic component *wherein the organic compound coordinates to the metal complex due to the joint vaporization*, at least under Patent Owner's assertions.

3. Dependent Claim 6: The organic electronic component according to claim 1, wherein the organic compound is selected from [Compounds I–XIII].

150. It is my opinion that as discussed in Section VIII.B.1, claim 1 is disclosed in Ma. It is my opinion that Ma discloses the additional elements in claim 6.

151. As discussed in Section VIII.B.1.c, Ma discloses BPhen as the organic compound for the ETL. Ma, 811. BPhen is Compound VI in the '223 patent, which is compound VI in claim 6. '223 patent, col. 6.

4. Dependent Claim 8: The organic electronic component according to claim 1, wherein at least parts of the organic compounds bridge two metal complexes together, so that a chain-like structure of the metal complexes is formed and/or at least parts of the organic compounds bridge more than two metal complexes together, so that a network-like structure of the metal complexes is formed.

152. It is my opinion that as discussed in Section VIII.B.1, Ma discloses a metal complex (Liq) and an organic compound (BPhen). Ma also discloses manufacturing processes that the '223 patent purports would achieve the additional elements in claim 8, as discussed below. Ma does not expressly disclose the structure

formed by Liq and BPhen upon vaporization, but I have been informed that Patent Owner has asserted that organic compounds with multiple coordination sites around rings (like the two nitrogens of BPhen or its delocalized π -electrons), when simultaneously vaporized with Liq, will form chain-like or network-like structures. I have accepted and applied this assumption in rendering my opinions. Based on that assumption, it is my opinion that Ma discloses and/or renders obvious this element in claim 8.

153. I observe that the '223 patent describes how compounds like BPhen can form chain-like structures when coordinated to certain metal complexes as discussed in Section VIII.A.6.

154. Moreover, Ma discloses the same vaporization process that, according to the '223 patent, ('223 patent, 1:60–62; *see also id.*, 11:17–29), allows for formation of chain-like or network like structures, wherein *at least parts of the organic compounds bridge two (or more) metal complexes together*. Ma discloses that the electron transport layer was formed by “conventional thermal evaporation in a high vacuum chamber with a base pressure of 1×10^{-5} Torr.” Ma, 811.

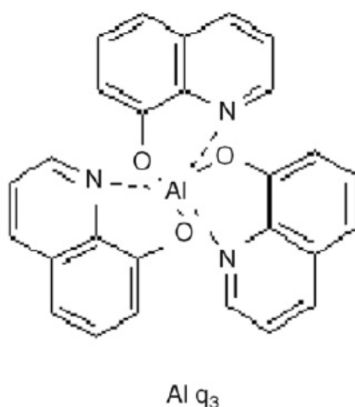
155. Accordingly, in my opinion, in light of Patent Owner’s assertion that Liq can coordinate with organic compounds with multiple coordination sites around rings (like the two nitrogens of BPhen or the delocalized π -electrons), and the '223 patent’s assertion that BPhen can form *chain-like or network-like structures* when

coordinated to a metal complex when simultaneously vaporized, Ma discloses this limitation. *See supra* Sections VIII.A.6.a. and VIII.A.6.b.

5. Dependent Claim 9: The organic electronic component according to claim 1, which is formed as an organic LED (OLED) which additionally comprises an organic emitting layer.

156. It is my opinion that as discussed in Section VIII.B.1, claim 1 is disclosed in Ma. It is my opinion that Ma discloses the additional elements in claim 9.

157. Ma discloses an organic light-emitting diode (OLED) formed using Liq and BPhen, wherein the emission layer is comprised of Alq₃. Ma, Abstract, 811.



Ma, 811, Fig. 1. It is my opinion that because Alq₃ is an organic compound, Ma discloses *an OLED which additionally comprises an organic emitting layer*.

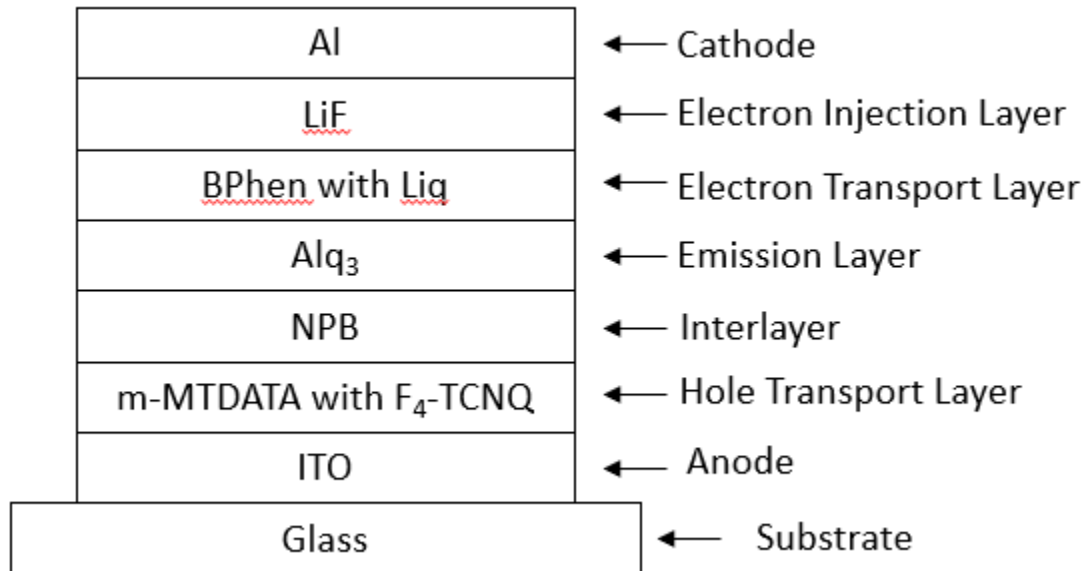
6. Independent Claim 10

- a) **Preamble: A method for manufacturing an organic electronic component, comprising the method steps of:**

158. Is it my opinion that to the extent the preamble is limiting, Ma discloses it. *Supra* Section VIII.B.1.a.

- b) **Element 10[a]: A) providing a substrate, B) applying a first electrode, C) depositing an electron-conducting layer on the substrate, D) applying a second electrode,**

159. Ma discloses this element. As shown in the schematic below, in Ma, the glass substrate is provided, and the ITO anode (i.e., *a first electrode*) is applied on the glass substrate. Ma, 811.



160. As discussed in Section VIII.A.8.b, it is my opinion that in the context of the '223 patent, Ma's electron transport layer is deposited on the substrate although it

is not directly deposited on the substrate.

161. Further, it is my opinion that Ma discloses forming an organic electroluminescence element by applying a second electrode composed of Al after depositing the electron transport layer, as recited by step D).

c) Element 10[b]: wherein the electron-conducting layer is deposited by means of simultaneous vaporization of a metal complex and an organic compound,

162. It is my opinion that Element 10[b] is identical to Element 1[b] except that Element 10[b] does not require that the metal complex comprise a central metal atom. Thus, it is my opinion that Ma discloses Element 10[b] by disclosing Liq regardless of the meaning of the term “central atom” for the same reasons as Element 1[b]. *Supra* Section VIII.B.1.c.

d) Element 10[c]: wherein the organic compound comprises a heteroaromatic compound which is conjugated with an aromatic compound via a C—C bond.

163. It is my opinion that Element 10[c] is identical to Element 1[c]. Thus, it is my opinion that Ma discloses Element 10[c] for the same reasons as Element 1[c]. *Supra* Section VIII.B.1.d.

7. Dependent Claim 11: The method according to claim 10, wherein during the simultaneous vaporization the organic compound coordinates in the gas phase to the metal complex.

164. It is my opinion that Ma discloses and/or renders obvious the additional elements in claim 11. I understand that the Patent Owner has specifically identified Liq

as such a metal complex that can coordinate to organic compounds in the gas phase during simultaneous vaporization. The '223 patent discloses that “[b]ecause of the simultaneous vaporization of metal complexes and organic compounds, both compounds are simultaneously present next to each other in the gas phase. This enables the organic compound to coordinate to the metal complex in the gas phase.” ’223 patent, 13:36–40. The ’223 patent specifically discloses that “[this] coordination can be effected for example via a heteroaromatic compound in the organic compound.” *Id.*, 13:40–42. And, BPhen has a heteroaromatic compound suitable for such coordination according to the ’223 patent. *See* ’223 patent, col. 6 (Compound VI). Thus, it is my opinion that under Patent Owner’s understanding, Liq similarly coordinate to BPhen in the gas phase during the simultaneous vaporization.

165. In the alternative, it is my opinion that a POSA would have been motivated to modify the parameters of deposition to achieve coordination of BPhen and Liq in the gas phase. In my opinion, a POSA would have understood that if the BPhen and Liq coordinate in the gas phase, the complex which is deposited will be coordinated BPhen and Liq. In my opinion, a POSA would also have understood that a deposited layer of coordinated BPhen and Liq will contain a more uniform distribution of BPhen and Liq, than if the BPhen and Liq were individually deposited such that coordination happens on the surface. It is my opinion that a POSA would have understood that a more uniform layer of coordinated BPhen and Liq would allow

for the more efficient transfer of electrons through that layer. In my opinion, a POSA would also have understood that a more uniform layer of coordinated BPhen and Liq would allow for the more efficient use of materials to make the electron conducting layer.

166. In my opinion, one way a POSA could have increased the likelihood of coordination of BPhen and Liq in the gas phase is through choosing a method of deposition that ensures a low vacuum in the reaction chamber. Ma discloses that the electron transport layer was formed by “conventional thermal evaporation in a high vacuum chamber with a base pressure of 1×10^{-5} Torr.” Ma, 811. It was well-known that it would be beneficial to increase the pressure in the vacuum chamber to use the OVPD method (in essence, using the Ma’s VTE method but increasing the pressure to 0.1–10 Torr) for its “precise control over the layer thickness and dopant concentration, while increasing materials use efficiency over that obtained by VTE.” Shtein, 4006. In my opinion, a POSA would have understood that when BPhen and Liq are jointly evaporated using the OVPD method, they would likely result in coordination in the gas phase rather than on the substrate because increasing the pressure of the reaction chamber would increase collision of the vaporized Liq and BPhen molecules, which in turn would result in coordination of these compounds in the gas phase.

8. Dependent Claim 12: The method according to claim 10, wherein the electron-conducting layer is deposited as a chain-like or network-like structure.

167. It is my opinion that as discussed in Section VIII.B.4, claim 10 is disclosed in Ma. As discussed in Section VIII.B.4, according to Patent Owner's contentions and the '223 patent, the coordination of the organic compound (BPhen) to the metal complex (Liq) would result in a chain-like structure being deposited.

9. Dependent Claim 13: The method according to claim 12, wherein the degree of cross-linking of the electron-conducting layer is controlled by the ratio between the metal complex and the organic compound during vaporization.

168. It is my opinion that as discussed in Section VIII.C.7, claim 12 is disclosed in Ma. Ma discloses the additional elements in claim 13.

169. As discussed in Section VIII.A.11, the '223 patent discloses that the degree of cross-linking in a layer is related to the electron conductivity of the layer. *See* '223 patent, 11:29–33, 13:61–67. In my opinion, Figure 5 of Ma shows that changing the ratio between Liq and BPhen alters the current density (i.e., electron conductivity) of the electron transport layer created in Ma.

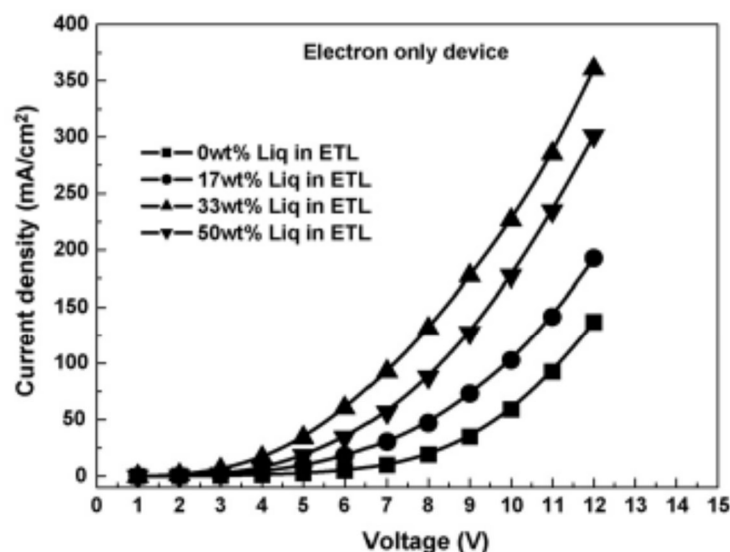


Fig. 5. Current density vs voltage characteristics of electron-only devices of 0 wt.%, 17 wt.%, 33 wt.% and 50 wt.% Liq doped into BPhen.

Ma, 812, Fig. 5. Fig. 5 of Ma shows that “[a]t the same voltage, the current density increases along with the increase in the doping ratio” and that “[t]he highest current density is observed at the doping ratio of 33 wt% Liq.” Ma, 813.⁵ The molecular weight (MW) of BPhen is 332.4 g/mole and the MW of Liq is 151.09 g/mole. Thus, 33 wt% Liq in BPhen corresponds to a molar fraction of 52.4% Liq in BPhen, which is approximately 1:1 molar ratio between Liq and BPhen.

⁵ I observe that Fig. 5 of Ma was obtained using “electron-only devices” in which the current consists mainly of electrons (Ma, 811). However, in my opinion, the same trend (where changing the ratio of Liq:BPhen changes the electron conductivity of the ETL layer) could be achieved using a complete electronic device including a hole transport layer.

170. Indeed, Ma teaches that “[t]hese J–V characteristics of electron-only devices suggest that a certain doping ratio of Liq to BPhen can improve the electron transport ability of the co-deposited layer.” Ma, 813. Specifically, Ma explains that a heavy doping concentration of Liq (greater than 1:2 BPhen:Liq) may lead to significant diffusion of the dopant into the emission layer and cause quenching. *Id.* Thus, Ma suggests that coordination of Liq and BPhen at the 1:1 ratio would yield the highest current density and that greater amounts of Liq would reduce the current density.

171. Thus, it is my opinion that Ma teaches an optimum ratio of the metal complex to the organic compound to achieve the best electron conductivity. In other words, Ma teaches that the electron conductivity *is controlled by the ratio between the metal complex and the organic compound during vaporization*. Because, the degree of cross-linking is related to the electron conductivity according to the ’223 patent (*see* ’223 patent, 11:29–33, 13:61–67), and, under Patent Owner’s assertions, Liq and BPhen can form chain- or network-like structures, it would have been obvious that *the degree of cross-linking [in the chain-like or network-like structures] is controlled by the ratio between the metal complex and the organic compound during vaporization*.

10. Dependent Claim 14: The method according to claim 10, wherein the organic compound does not coordinate to the metal complex prior to vaporization.

172. It is my opinion that as discussed in Section VIII.C.6, claim 10 is disclosed in Ma. It is my opinion that Ma discloses the additional elements in claim 14.

173. Ma discloses that “[i]n the co-deposition process [of ETL], organic sources [for Liq and BPhen] were independently controlled” and that “[t]he deposition rates for the co-deposition layer were monitored using two independent quartz sensors.” Ma, 811. In my opinion, because Liq and BPhen are contained in two independent sources prior to vaporization, there is no opportunity for the BPhen and Liq of Ma to coordinate prior to vaporization. Accordingly, Ma discloses this element.

IX. AVAILABILITY FOR CROSS-EXAMINATION

174. In signing this declaration, I recognize that the declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I also recognize that I may be subject to cross examination in the case and that cross examination will take place within the United States. If cross examination is required of me, I will appear for cross examination within the United States during a time as mutually agreed between the parties.

X. RIGHT TO SUPPLEMENT

175. I reserve the right to supplement my opinions in the future to respond

to any arguments that the Patent Owner raises. This declaration represents only those opinions that I have formed to date. I reserve the right to revise, supplement, and/or amend my opinions stated herein based on new information that becomes available to me and on my continuing analysis of the materials already provided.

XI. JURAT

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

* * *

I, Dr. Barry P. Rand, declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct.



Executed on July 2, 2024