

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

**SAVANT TECHNOLOGIES LLC d/b/a GE LIGHTING,
ELONG INTERNATIONAL USA INC., AND
XIAMEN LONGSTAR LIGHTING CO. LTD.**
Petitioners,

v.

FEIT ELECTRIC COMPANY, INC.,
Patent Owner.

Case No. IPR2025-00260

Patent No. 8,604,678

**DUPLICATE DECLARATION OF
WILLIAM A. DOOLITTLE, PH.D. SUMMITTED IN
IPR2024-01357**

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

**SAVANT TECHNOLOGIES LLC d/b/a GE LIGHTING
and LEDVANCE LLC,**
Petitioners,

v.

FEIT ELECTRIC COMPANY, INC.,
Patent Owner.

Case No. IPR2024- 01357

Patent No. 8,604,678

DECLARATION OF WILLIAM A. DOOLITTLE, PH.D.

TABLE OF CONTENTS

TABLE OF CONTENTS.....	i
EXHIBIT LIST.....	iv
I. INTRODUCTION	1
II. EXPERIENCE AND QUALIFICATIONS	1
III. STATUS AS AN INDEPENDENT EXPERT WITNESS	7
IV. MATERIALS CONSIDERED AND BASIS OF OPINIONS	7
V. LEGAL STANDARDS.....	8
A. Invalidity	8
B. Claim Construction.....	10
VI. DESCRIPTION OF THE RELEVANT FIELD AND TIMEFRAME	11
VII. PERSON OF ORDINARY SKILL (“POSA”)	12
VIII. TECHNICAL BACKGROUND	14
A. Background of LEDs and Light Diffusing Materials.....	14
B. Blue-light LED chips led to white-light LED light sources	26
C. White-light LED light sources were improved with a TiO ₂ -containing light diffusing layer.....	29
D. Summary of the ’678 Patent.....	31
E. Prosecution History of the ’678 Patent.....	33
IX. OPINIONS ON CLAIM CONSTRUCTION	35
X. SUMMARY OF INVALIDITY POSITIONS	36
XI. PRIOR ART REFERENCES.....	37
A. Basin-2005 (Pub. No. US2007/0045761; EX1006).....	37
B. Basin-2007 (Pub. No. US2009/0057699; EX1005).....	38
C. Krummacher (Pub. No. US2008/0079015; EX1007)	39
D. Stokes (Pat. No. 6,791,259; EX1008)	40
E. Shimizu (Pat. No. 6,069,440; EX1010) and Shimizu-APA (Pat. No. 5,998,925; EX1009).....	45
F. Hussell (Pub. No. US2010/0124243; EX1021)	46

XII. GROUND OF OBVIOUSNESS	47
[GROUND 1] Claims 1-3, 6, 7, 9, 10, 16-21, 25, and 26 are rendered obvious by Basin-2007 and Basin-2005	47
Independent Claim 1: Wavelength Conversion Component	48
Claim 2: Layers in Direct Contact.....	55
Claim 3: Layers in Light Transmissive Binder	56
Claim 6: Light Transmissive Binder is Silicone	58
Claim 7: Weight Loading of Light Scattering Material	60
Claim 9: Deposition Methods	60
Claim 10: Light Scattering Material is TiO ₂	61
Claim 16: Planar Shapes	62
Claim 17: Dome or Elongated Dome Shaped Light Diffusing Layer	62
Claim 18: Wavelength Converting Layer Beneath the Dome	63
Independent Claim 19: Light Emitting Device	64
Claim 20: Applications for the Light Emitting Device	65
Claim 21: Improved Off-State White Appearance.....	65
Claim 25: Planar Shapes	66
Claim 26: Dome Shaped Light Diffusing Layer	67
[GROUND 2] Claims 19, 20, and 29 are rendered obvious by Hussell, Basin-2007, and Van Woudenberg.....	67
[GROUND 3] Claims 1, 2, 3, 6, 10, 16, 19, 21, and 25 are rendered obvious by Krummacher and Stokes (incorporating Shimizu).....	84
Independent Claim 1: Wavelength Conversion Component	84
Claim 2: Layers in Direct Contact.....	93
Claim 3: Layers in Light Transmissive Binder	94
Claim 6: Light Transmissive Binder is Silicone	98
Claim 10: Light Scattering Material is TiO ₂	100
Claim 16: Planar Shapes	100
Independent Claim 19: Light Emitting Device	101

Claim 21: Improved Off-State White Appearance.....	102
Claim 25: Planar Shapes	107
[GROUND 4] Claims 19, 20, and 29 are rendered obvious by Hussell, Krummacher, and Van Woudenberg	107
XIII. SECONDARY CONSIDERATIONS	109
XIV. CONCLUSION	109

EXHIBIT LIST

No.	Description
EX1001	U.S. Patent No. 8,604,678
EX1002	Declaration of William A. Doolittle, Ph.D.
EX1003	Curriculum Vitae of William A. Doolittle, Ph.D.
EX1004	File History for U.S. Pat. Appl. No. 13/273,212 (excl. references)
EX1005	U.S. Pat. Pub. No. 2009/0057699 (“Basin-2007”)
EX1006	U.S. Pat. Pub. No. 2007/0045761 (“Basin-2005”)
EX1007	U.S. Pat. Pub. No. 2008/0079015 (“Krummacher”)
EX1008	U.S. Patent No. 6,791,259 (“Stokes”)
EX1009	U.S. Patent No. 5,998,925 (“Shimizu-APA”)
EX1010	U.S. Patent No. 6,069,440 (“Shimizu”)
EX1011	U.S. Pat. Pub. No. US2010/0124243 (“Hussell”)
EX1012	DuPont: Polymers, Light and the Science of TiO ₂ (2007)
EX1013	DuPont: Titanium Dioxide for Coatings (2007)
EX1014	Erik S. Thiele and Roger H. French, “Computation of Light Scattering by Anisotropic Spheres of Rutile Titania”, Adv. Mater. 1998, 10, No. 15
EX1015	Erik S. Thiele and Roger H. French, “Light-Scattering Properties of Representative, Morphological Rutile Titania Particles Studied Using a Finite-Element Method”, J. Am. Ceram. Soc., 81 [3] 469–79 (1998)
EX1016	Robert W. Johnson, Erik S. Thiele, And Roger H. French, “Light-scattering efficiency of white pigments: an analysis of model core - shell pigments vs. optimized rutile TiO ₂ ”, TAPPI JOURNAL, November 1997, Vol. 80(11)
EX1017	William D. Ross, “Theoretical Light-Scattering Power of TiO ₂ and Microvoids”, Ind. Eng. Chem., Prod. Res. Develop., Vol. 13, No. 1, 1974
EX1018	Feit Electric’s Initial Infringement Contentions - Claim Charts (May 28, 2024)
EX1019	U.S. Patent No. 8,547,010 (“Jagt”)
EX1020	Int’l Pat. Pub. No. WO 2008/044171 A2 (“Van Woudenberg”)

I, William A. Doolittle, Ph.D., of Atlanta, Georgia, USA, hereby declare as follows.

I. INTRODUCTION

1. I am over the age of eighteen and otherwise competent to make this declaration.

2. I have been retained by Radulescu LLP on behalf of Savant Technologies LLC d/b/a GE Lighting and LEDVANCE LLC, to provide an analysis of the scope and content of U.S. Patent No. 8,604,678 (“the ’678 patent”) (EX1001). My analysis relates to claims 1-3, 6, 7, 9, 10, 16-21, 25, 26, and 29 of the ’678 patent.

3. This declaration summarizes the opinions I have formed to date. I reserve the right to modify my opinions, if necessary, based on further review and analysis of information that I receive after the filing of this declaration, including in response to positions taken by Patent Owner or their experts that I have not yet seen.

II. EXPERIENCE AND QUALIFICATIONS

4. I have summarized in this section my educational background, career history, publications, and other relevant qualifications.

5. I am the Joseph M. Pettit Professor in the School of Electrical and Computer Engineering at Georgia Institute of Technology (“Georgia Tech”). A

complete history of my employment history, honors and awards, and scholarship can be found in my *curriculum vitae*, submitted as EX1003 with this declaration.

6. I received my B.E.E. with highest honors in Electrical Engineering in 1989 from Georgia Tech. I then received a Ph.D. in Electrical and Computer Engineering in 1996 from Georgia Tech.

7. After working as a research engineer for the university, I began my career as a professor in the year 2001, where I progressed from assistant professor, to associate professor, and finally to a full professorship in 2012. I now hold an endowed professorship at the university as the Joseph M. Petit Professor of Georgia Tech.

8. I have worked with, studied, and taught about III-Nitride materials, LEDs and phosphors in particular for more than 25 years. In addition, I have taught classes and been a world leader in research conferences on the same technologies for more than 20 years.

9. I pioneered the area of hyper doping of wide bandgap semiconductors including increasing certain conduction figures of merit known as hole concentrations to 40 times what previously had been thought as the limit. This enabled the creation of new devices that utilize quantum mechanical processes to reduce power losses and to allow new ways of interconnecting advanced power and optoelectronic devices including LEDs.

10. I have won numerous awards for my teaching and research, including the 2004 National Science Foundation CAREER Award to study the integration of single crystal ferroelectrics with wide bandgap semiconductors through epitaxial processes. The research involved the epitaxial growth of III-V thin film semiconductor layers, and in particular III-Nitride structures and devices. I have also won Multidisciplinary University Research Initiative awards for Epitaxial Multifunctional Materials and Applications, Laboratory Instrumentation Design Research for Scalable Next Generation Epitaxy, and Cross Disciplinary Electronic Research Enabling Biologically Realistic Autonomous Learning, and numerous teaching awards.

11. From 2003-2009, I was the first assistant professor to win a MURI award, one of the most prestigious grants in the semiconductor field. In fact, I was lead PI on two Multidisciplinary University Research Initiatives (MURI) programs as an assistant professor focusing on the development of next generation epitaxial systems for three-dimensional epitaxy and on the development and exploitation of epitaxial multifunctional oxides. This latter MURI was an extension of my NSF CAREER award and led to a new branch of science in multifunctional materials. I was also awarded and am currently the lead PI on a third MURI program aimed at using quantum phenomena to build nanoscale devices that operate in analogy to various brain functions. I am also currently co-principal investigator on a 4th

MURI looking at the nanoscale engineering of thermal interfaces so as to improve heat dissipation in III- Nitride power electronics while maintaining high crystalline quality.

12. I am a co-inventor of 12 US patents and three foreign patents including semiconductor toolsets, epitaxy tools, device structures including a patented (US Patent 7,888,669 B2, “Nitride/Zinc Oxide Based Light-Emitting Diodes.” February 15, 2011) white light emitting LED that uses a self-luminescent substrate as an alternative to traditional phosphors for the conversion of blue/UV light to white light. As such I have detailed understanding of light emitting device designs, materials all mechanisms for luminescence including but not limited to photoluminescence, electroluminescence, fluorescence and phosphorescence.

13. I have been recognized multiple times by my international peers as a leader in the field having been asked to Chair (the lead role) the two biggest conferences in the III-Nitride area (International Workshop on Nitride Semiconductors and the International Conference on Nitride Semiconductors) in 2016 and 2019. Additionally, I have been program chair (responsible for selecting from thousands of submissions the most cutting-edge papers for inclusion in the conference) for these conferences several times. My leadership roles in these meetings provides me with a broad understanding as to what is the state of the art in the academic, industrial and commercial fields of solid state lighting and III-

Nitride semiconductor technology. My longevity in the field provides me with a historical record of what was the state of the art at various times.

14. I am currently director of the Advanced Semiconductor Technology Facility with an estimated equipment capitalization of \$6 million, and funded research since year 2000 totaling almost \$42 million.

15. To date, I have advised and graduated two dozen Ph.D. students, 12 master's students and 45 undergraduate students and have taught over 1000 undergraduates and over 175 graduate students in all aspects of microelectronics, optoelectronics and semiconductor science and technology.

16. I have published over 186 refereed journal and conference papers and conference proceedings in the subject matter areas of compound semiconductor materials and devices for detectors. These works have been published in journals including Advanced Materials, Journal of Crystal Growth, Journal of Applied Physics, IEEE Journal of Photovoltaics, Electronic Materials Letters, and Current Topics in Solid State Physics, among many others.

17. I am the founder of two companies, Innovative Advanced Materials Inc. and Innovative Advanced Technologies. Both companies focus on commercialization of state-of-the-art epitaxial growth systems that bridge the benefits of the two most popular growth methodologies, metal-organic chemical vapor deposition (MOCVD) and molecular beam epitaxy (MBE).

18. I have been awarded numerous grants and have published numerous papers that examine III-Nitride light-emitting diodes (LEDs) (including ultraviolet (UV) LEDs), solar cells, photodetectors and various transistors including high electron mobility transistors (HEMTs) and heterojunction bipolar transistors (HBTs) as well as the fundamental physics of III-Nitride epitaxial growth.

19. I have given over 150 talks and seminars in the U.S. and abroad, including over 35 invited and keynote addresses. I am also a Senior Member of the Institute of Electrical Electronic Engineering (IEEE). I have twice (2016 and 2019) been selected by a diverse international advisory committee made up of some of the most prominent scientists in the III-Nitride semiconductor community to lead (Chair) the two largest conferences in the field: the International Workshop on Nitride Semiconductors (IWN 2016) and the International Conference on Nitride Semiconductors (ICNS 2019). Additionally, I have served as a program chair selecting the best contributions and organizing lectures for each of these meetings in 2010/2024 (IWN) and 2013/2017 (ICNS). In these capacities, I have not only been recognized as an international leader in the field but also as an expert in what the entire III-Nitride community is doing.

20. Based on the above education and experience, I believe that I have a detailed understanding of the state of the art during the relevant period, as well as a

sound basis for opining how persons of skill in the art at that time would understand the technical issues in this case.

III. STATUS AS AN INDEPENDENT EXPERT WITNESS

21. As noted above, I have been retained in this matter by Radulescu LLP on behalf of Savant Technologies LLC d/b/a GE Lighting and LEDVANCE LLC (“Petitioners”) to provide analysis on the scope and content of the ’678 patent relative to the state of the art at the time of the earliest application underlying the ’678 patent, which I understand to be on or about October 5, 2010. My analysis relates to claims 1-3, 6, 7, 9, 10, 16-21, 25, 26, and 29 of the ’678 patent.

22. I am being compensated at the rate of \$450 per hour (plus any expenses) for my work and testimony. My fee is not contingent on the outcome of any matter or on any of the technical positions I explain in this declaration. I have no financial interest in Petitioners.

23. I have been informed that Feit Electric Company, Inc. is the owner of the ’678 patent. I have no financial interest in Patent Owner or the ’678 patent nor to my recollection have I ever had any contact with the Patent Owner or the listed inventors of the ’678 patent.

IV. MATERIALS CONSIDERED AND BASIS OF OPINIONS

24. My opinions are based on more than 30 years of studying, teaching about, and directly working with light emitting diodes. My opinions are also based

on investigation and study of the relevant materials, including the patent at issue and its file history, and the prior art. In the course of forming my opinions I have reviewed all the exhibits of record.

25. I may rely upon these materials and/or additional materials to rebut arguments raised by the Patent Owner. Further, I may also consider additional documents and information in forming any necessary opinions – including documents that may not yet have been provided to me.

26. My analysis of the materials relevant to this proceeding is ongoing and I will continue to review any new material as it is provided. This declaration presents only those opinions I have formed to date. I reserve the right to revise, supplement, and/or amend my opinions stated herein based on new information and on my continuing analysis of the materials already provided.

V. LEGAL STANDARDS

A. Invalidity

27. I have been advised by counsel on the law regarding invalidity. I understand that for the purposes of this proceeding a patent claim may be found invalid as anticipated or obvious.

28. I have been advised that a patent claim can be invalid if it is anticipated in view of the prior art. I understand that anticipation of a claim

requires that every element of a claim be disclosed expressly or inherently in a single prior art reference, arranged as in the claim.

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

30. The '678 patent claims priority to an application filed as early as October 5, 2010. For purposes of my analysis here, I have applied a date of October 5, 2010 as the date of the alleged invention in my obviousness analysis, although in many cases the same analysis would hold true even if the date of the alleged invention occurred earlier than October 5, 2010 (especially given the earlier publication or filing dates of the prior art discussed herein).

31. I have been informed that a claim can be obvious in light of a single prior art reference or multiple prior art references. To be obvious in light of a single prior art reference or multiple prior art references, there must be a reason that would have prompted a POSA to modify the single prior art reference, or

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

B. Claim Construction

32. I understand that, for purposes of my analysis in this proceeding, the terms appearing in the patent claims should be interpreted according to their “ordinary and customary meaning.” In determining the ordinary and customary meaning, the words of a claim are first given their plain meaning that those words would have had to a POSA. I understand that the structure of the claims, the specification, and the file history also may be used to better construe a claim insofar as the plain meaning of the claims cannot be understood. Moreover, treatises and dictionaries may be used, albeit under limited circumstances, to determine the meaning attributed by a person of ordinary skill in the art to a claim term at the time of filing. I have followed this approach in my analysis, and for all

of the claim terms considered in this declaration, I have applied the plain and ordinary meaning of those terms unless otherwise specifically indicated.

33. I also understand that the words of the claims should be interpreted as they would have been interpreted by a POSA at the time the alleged invention was made.

VI. DESCRIPTION OF THE RELEVANT FIELD AND TIMEFRAME

34. I have carefully reviewed the '678 patent. For convenience, the information that I considered in arriving at my opinions is listed in the Exhibit List above.

35. Based on my review of these materials, I understand that the relevant field for purposes of the '678 patent is solid-state light emitting devices. (EX1001, 1:24-26.)

36. I understand the relevant timeframe for my analysis is the time preceding October 5, 2010, which is the date of the earliest filing to which the '678 patent claims priority. (EX1001, [60].)

37. As described above, I have extensive experience in the relevant field, including experience relating to the characteristics and output of light emitting devices, including the use of phosphor wavelength conversion layers and TiO₂ light diffusing layers. Based on my experience, I have an established understanding of the relevant field in the relevant timeframe.

VII. PERSON OF ORDINARY SKILL (“POSA”)

38. I have been informed that “a person of ordinary skill in the relevant field” is a hypothetical person to whom an expert in the relevant field could assign a routine task with reasonable confidence that the task would have been successfully carried out. I have been informed that evidence of the level of ordinary skill in the art can be determined based on information about the field including: the types of problems encountered, known solutions, the speed of innovation, sophistication, and the educational level of active workers. I also understand that the ’678 patent itself and its description are evidence of the level of skill in the art. I have considered this information along with my own background working with students and other professionals in the field to reach my conclusion.

39. Important to my analysis is the specification of the ’678 patent, which implies that the technology is relatively simple to a person of skill in the art. Many of the materials used are referred to generically, rather than by providing specific examples. Similarly, the process steps and structures are identified, at most, at a high level. Instead of providing details, the ’678 patent leaves the reader to fill in those details based on cited references and his or her knowledge and experience. I agree with the ’678 patent’s implication that the technology is simple, and that the specific implementation details for a white-light LED light source would have been within the ordinary level of skill in the art at the relevant time.

40. Therefore, it is my opinion that the person of ordinary skill (which I may refer to as a POSA) in the art at the relevant time would have had an undergraduate degree (i.e., B.S., B.S.E. or the equivalent) in electrical engineering, materials science, physics, or a similar discipline. A POSA would also have one to two years of experience in the field of LED packaging design. More education could substitute for experience, and vice versa. This person would have been capable of understanding and applying the teachings of the '678 patent and the prior-art references discussed herein.

41. In my opinion, the level of skill is informed by the relative detail provided in the '678 patent and the references relied on in the petition. That is, the applicants for the '678 patent did not invent white-light LED light sources or the blue-light LED chips that made them possible. The '678 patent acknowledges those as the invention of others, explaining that “[w]hite light emitting LEDs (“white LEDs”) [light sources] are known” and citing to Shimizu-APA for teaching such light sources. (EX1001, 1:30-50.) The '678 patent further acknowledges that “[d]ue to their long operating life expectancy (>50,000 hours) and high luminous efficacy (70 lumens per watt and higher) high brightness white LEDs are increasingly being used to replace conventional fluorescent, compact fluorescent and incandescent light sources.” (EX1001, 1:51-55.) Nor did the applicants invent the use of a light diffusing layer containing TiO₂ particles.

Indeed, the use of a light diffusing layer to improve the appearance of a white light LED light source was well within the level of ordinary skill of a POSA.

42. Based on my experience, I have an understanding of the capabilities of a person of ordinary skill in the relevant field. I have supervised, directed, and instructed many such persons over the course of my career and was doing so in the fall of 2012.

VIII. TECHNICAL BACKGROUND

43. This technical background is meant as a primer for the reader.

A. Background of LEDs and Light Diffusing Materials

Semiconductors as Light Emitting Components and Light Diffusing Components

44. Semiconductor materials are used both to emit light and to scatter light in LEDs. Semiconductors have a property called an energy bandgap (often just stated as “the bandgap”) related to the energy required to break an electron off the atoms, allowing the electrons to freely conduct throughout the material. The bandgap affects both the color of light emitted from a semiconductor and the range of colors of light that freely transmit through the semiconductor.

45. LEDs emit light having a particular color based on the bandgap of the semiconductor that the LED is made of as defined by the equation $E_g = 1.24/\lambda$ where E_g = the bandgap in eV and λ is the wavelength of light emitted in microns. Selection of the semiconductor used determines the light that the LED emits.

46. Likewise, which color (wavelengths) of light passing through a semiconductor that is absorbed or transmitted is largely based on the energy bandgap. Light with energy greater than the bandgap (shorter wavelengths) is strongly absorbed whereas light with energy less than the bandgap (longer wavelengths) is very weakly absorbed. Because visible light is roughly from 400 nm to 700 nm as illustrated below, or corresponding to energies from ~ 3.1 to 1.8 eV, the 3.0 to 3.2 eV bandgap TiO_2 semiconductor particles are transparent to all visible colors but absorb UV light. This makes use of TiO_2 particles common in consumer products from paints to sunscreen ointments (*see, e.g., EX1003*). Thus, as discussed later, the optical properties of the TiO_2 containing layers are primarily due to the small particle size and not the fundamental properties of the semiconductor (except its optical index of refraction).

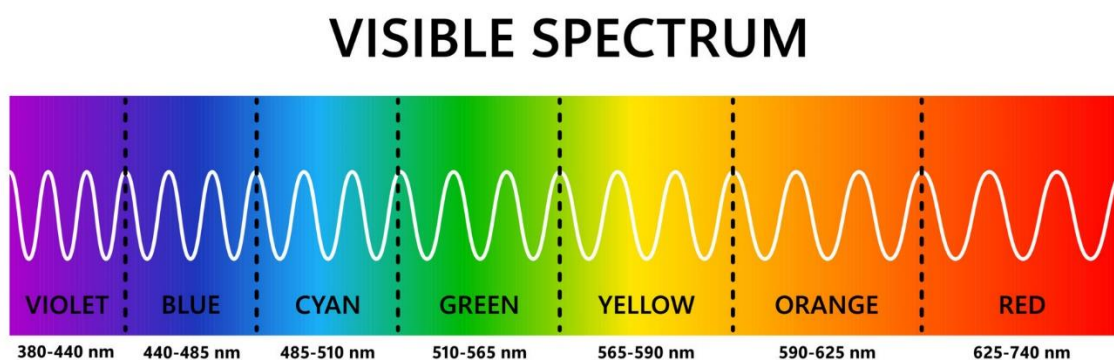


Image Credit: <https://perma.cc/L6MZ-K3SX>

47. LEDs that emit red light were developed in the 1960s. Red light has the lowest energy of wavelengths in the visible light range. Over the next 30 years, LEDs that emit red, orange, and yellow light using gallium arsenide (GaAs) and gallium phosphide (GaP) based semiconductors and their indium related derivatives were developed. However, blue LEDs and phosphor-converted LEDs required wide-bandgap materials that were not developed until much later.

48. The first “candela-class” blue-light emitting LED was described in the literature in 1994. The term “candela-class” refers to a device bright enough to be capable of being used for illumination. A candela is a unit of measure that historically referred to the luminous intensity of a standard candle. This LED used gallium nitride (GaN)-based semiconductors, which encompass indium gallium nitride and aluminum gallium nitride. Since 1994, GaN-based LEDs have been made brighter and made to emit wavelengths varying from ultraviolet (UV) to green.

49. Colored LEDs have been used for decades for signaling or large displays. Displays use multiple red, green, and blue LEDs arranged close together to form individual pixels including pixel combinations that appear white. But after the development of blue and UV GaN-based LEDs, these newer singular LEDs were combined with phosphors, which made generating white light for general illumination using LEDs feasible.

Phosphors

50. Phosphors are materials that are primarily used to convert light from one wavelength to another. Phosphors have existed for many decades and have been thoroughly developed for use in fluorescent lights, later applied to use with LEDs. If you have ever mistakenly broken a fluorescent tube light, you may have seen the white powder coating on the inside of the bulb. This is one or more of several colors of phosphors used to convert the UV light from an arc running throughout the tube to white light humans perceive. Phosphors absorb light (UV or blue light) from one narrow band of wavelengths and emit light at another band of wavelengths longer than the absorption wavelengths.

51. The process of converting light from one wavelength to a longer wavelength loses some energy, even with ideal phosphors. Because the shorter wavelengths carry more energy, the process of converting light from a “primary” shorter wavelength to “secondary” light with a longer wavelength entails losing some energy efficiency. The primary light (blue or UV light from the LED) must be absorbed by the phosphor with only a small percentage (typically about 10%) of the primary light escaping unabsorbed and because the secondary light emitted from the phosphor must escape the layer without further absorption, the thickness of the phosphor is important: thick enough to absorb the majority of the primary

light and thin enough that some of the primary light and most of the secondary light escapes.

52. Phosphors can be used to emit white light from blue emitting LEDs by absorbing a portion of the blue light and converting it to lower-energy red, green, or yellow light. The combination of blue light from the LED and light from the phosphors appears white. Because humans perceive blue + yellow light as white light, this is a particularly useful combination (blue LED + yellow phosphor) resulting in an inexpensive and energy efficient white light source. UV LEDs operate similarly, except they generally absorb all the light from the LED and emit blue, red, yellow, and/or green such that the combination appears white.

Specular Versus Diffuse Reflection

53. It is widely known that red colored surfaces absorb all colors except those of red wavelengths, reflecting red colors to an observer. Likewise white colors reflect all colors, absorbing no visible light. But the light being reflected comes from a source, whether the sun, an artificial light source, or reflected from the walls of a room. Inherently this light contains spatial information which appears to a human as an image that if exposed to a simple reflecting mirror (specular reflecting mirror as shown below) would return this spatial information (image) to the observer. In other words, the light observed from a specular mirror would retain the image of its original source such as one's own reflection. To

obtain a truly white, red, or other color appearance, the object must randomize all spatial information, making the reflected light absent of any room or source image.

54. Red surfaces randomize the reflected red light to lose the spatial information (images). Likewise white surfaces must randomize the reflected light for all colors of light, reflecting all colors but scattering the light enough that the original image (light source or room image) is lost. This randomizing medium is called a “diffuse medium” (see figure below) and thus, “diffusive mediums” are synonymous with “scattering mediums.” The figure below describes specular (reflections retaining the image spatial information) and diffusive (reflections destroying the image spatial information) surfaces. But such surfaces are subject to environmental changes like aging, corrosion etc. that could affect the light properties. As is described below, there is a better way to create diffusive/scattering mediums using particles that are not exposed to atmosphere or degradation sources.

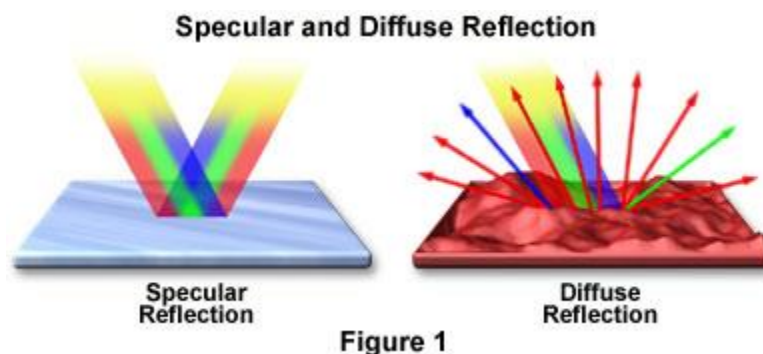


Figure 1
Image Credit: <https://perma.cc/T3KW-UBHQ>

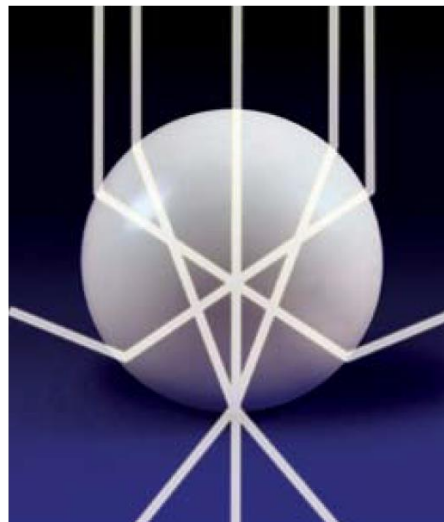
Embedded Particle Based Light Diffusing/Scattering

55. Here we first consider the light coming from the room when the LED is powered off. Reflective, scattering and diffusing particles like titanium dioxide (TiO_2) have been known to affect light for many generations and are commonly embedded in other transparent materials. Consider the ability of TiO_2 particles embedded in other transparent materials to “cover” the color/appearance of underlying materials (for example a yellow phosphor) on which it is deposited resulting in a white appearance: TiO_2 is well known to be a coloring pigment in white paint. Dupont states “Titanium dioxide (TiO_2) is the most important white pigment used in the coatings industry. It is widely used because it efficiently scatters visible light, thereby imparting whiteness, brightness and opacity when incorporated into a coating.” (EX1013, p.4.)

56. But since TiO_2 is a wide bandgap semiconductor comparable to GaN in optical properties, its optical scattering, diffusing, and reflecting properties largely result from the small particle size and not its fundamental properties (other than refractive index). That is, “titanium dioxide (TiO_2) and other white pigments opacify paint films primarily by diffusely reflecting light. This reflection occurs because the white pigment scatters or bends light strongly. If there is enough white pigment in a paint film, almost all visible light striking it ... will be reflected, and the film will appear opaque, white, and bright... The primary control of opacity

and brightness in white paint films depends on scattering of light. Scattering of light means bending of light, and in coatings, light can be bent by surface reflection, by refraction and by diffraction.” (EX1013, p.5.)

57. TiO_2 particles embedded in a transparent material (TM) appear white because of multiple scattering events, not on a surface, but inside the TiO_2 -TM layer that results in broad wavelength reflection. First considering how TiO_2 particles scatter light, the figure below shows how light can be refracted using a small transparent particle. TiO_2 is a semiconductor with a bandgap large enough to allow visible light to pass through it, making TiO_2 transparent. Light following various paths represented by the lines below are strongly redirected exiting the particle in different directions than it entered. This effect is known as “refraction based light scattering” and has been known for many decades.

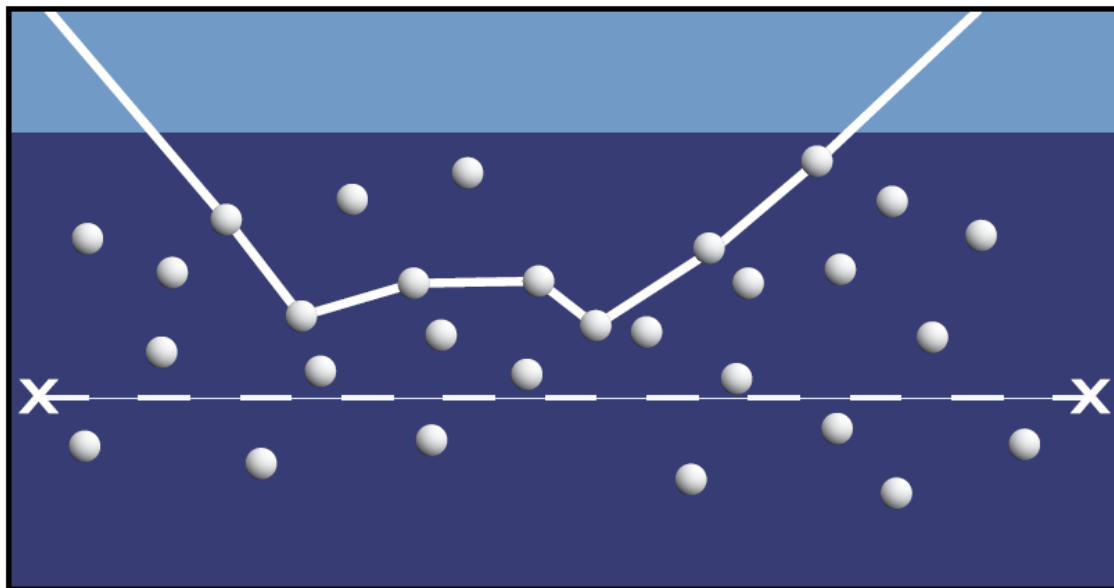


Higher Refractive Index

(EX1013, p.5.)

58. When multiple such scattering events occur as in a film containing many TiO_2 particles as shown below, the entering light undergoes multiple random scattering events and eventually escapes the scattering/diffusing layer implementing a randomized reflector. Random (multiple scattering) reflectors are different than the commonly thought of mirror reflectors in that unlike a specular mirror reflector that preserves both the color content (white light) and the image impinging on the mirror, a randomized diffusive reflector reflects no image but does preserve the white color of the impinging light. Since the incoming room light contains multiple colors (i.e. white light) the exiting scattered/diffused light also appears white but without any image – creating a white appearance.

Figure 3. Path of Light in White Paint Films.



High R.I. Pigment

(EX1013, p.6.)

Transmitted LED Primary Light in Particle Dispersed Mediums

59. The prior section described how random scattering of room light could result in a white reflective surface that covers (is opaque) underlying layers (like a yellow phosphor) giving a white appearance. But the same random scattering process and a different process known as diffraction can affect a powered-on LED emitted light that is transmitted through a TiO_2 -TM layer as well.

60. For general illumination applications, consumers prefer a light source with as little as possible angular dependence. But as shown below, a typical LED has a direction varied light emission. For example in the simplistic LED with clear and diffuse (scattering) lenses below, the 100% light intensity (brightest emission) is improved by adding a light scattering (diffuse) cover lens.

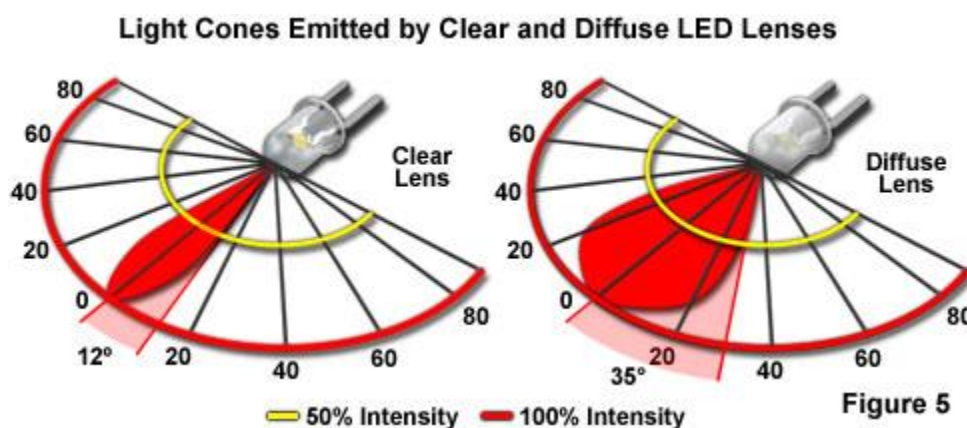


Image Credit: <https://perma.cc/2MJL-D66U>

61. Similarly, by adding light scattering particles, like TiO_2 , the exiting LED light can be homogenized to provide a wider emission angle. This can be

done by both refraction as described previously for room light reflection to obtain a white appearance and by diffraction.

62. First consider that since the refractive scattering by the TiO_2 particles is random, some light is scattered out of the device providing the blue content of the white light but with a wider emission angle than inherent to the LED chip itself. But there also exists a different mechanism for scattering outgoing blue light from the LED – diffraction. Dupont describes the phenomena of diffraction in the following way on page 6 of EX 1013:

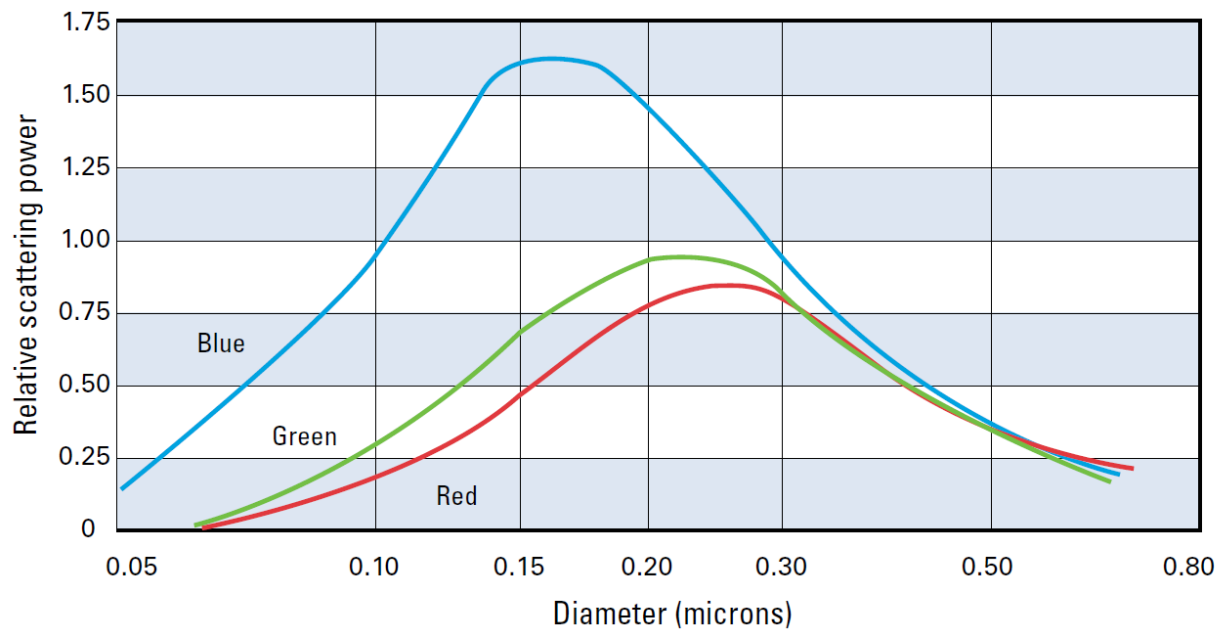
“The phenomenon of diffraction can be approached by consideration of one characteristic of wave motion. When a wave passes an obstruction, it tends to bend from its original path. As an example, waves of water passing a vertical piling will bend in behind the piling. The same is true of light waves as they pass near an object, they tend to bend behind the object. With large objects the amount of bending is generally insignificant to the eye, but when the object’s dimensions approach the wavelength of incident light, bending (diffraction) becomes appreciable. When the size of the TiO_2 particles approaches half the wavelength of incident light, the particles can bend four to five times as much light as actually falls on the particle because a large amount of the light is diffracted when it passes close to the particles. In other words, the scattering cross section can be four to five times the geometric cross

section of the particles.”

63. So, it has been well known that diffraction can occur when light interacts with small particles of TiO_2 (and similar materials) of size comparable to the wavelength of the light. This wavelength-particle size relationship leads to a color variation in the effectiveness of light scattering via the diffraction mechanism. This makes small wavelength light like the primary blue light from a directional LED scatter more than larger wavelength secondary light from a yellow, green, or red phosphor. But since the secondary light is already randomly oriented due to the random orientation of the phosphor particles, the mixture of randomized (diffraction + refraction scattered) blue light and randomized yellow phosphor light (random origination + refraction scattered) results in a more uniform illumination intensity with angle of viewing.

64. Thus, the most directional light, the LED light, can undergo “additional” diffraction to randomize its escape angle. To do this, one must select the correct particle size to affect the blue light more so than other colors. But this is also known. For example, Dupont shows in EX1013 (page 8) that at 150 nm (0.15 microns), the light scattering power of TiO_2 for blue light is substantially stronger than that of green or red light as shown in the figure below: “at 0.15 microns, the diameter corresponding to maximum scattering of blue light, light scattering in the red and green regions drops markedly.”

Figure 7. Relative Light Scattering Power versus Rutile Particle Size.



(EX1013, p.8.)

B. Blue-light LED chips led to white-light LED light sources

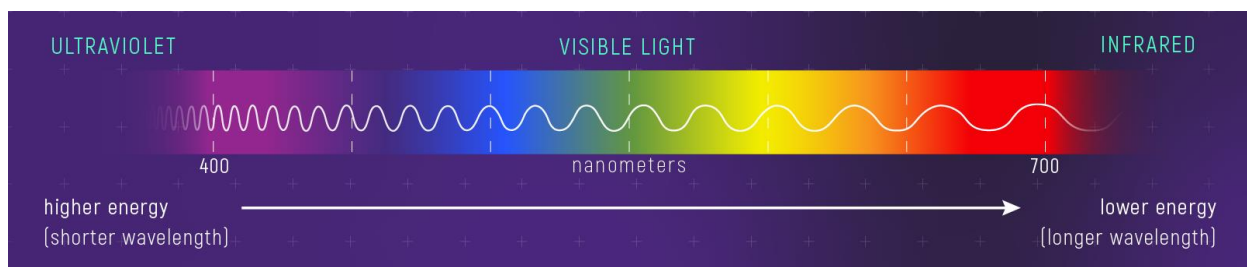
65. As reflected in the Background of the '678 patent and as discussed above, it was the development of high-efficiency blue-light LED chips that allowed for white-light LED light sources for replacing fluorescent and incandescent light sources. (EX1001, 1:30-46.) The '678 patent cites Shimizu as an example of such a white-light LED light source. (*Id.*) As the '678 patent states:

Typically, the LED chip or die generates blue light and the phosphor(s) absorbs a percentage of the blue light and re-emits yellow light The portion of the blue light generated by the LED that is not absorbed by the phosphor material combined with the light emitted by the phosphor provides light which appears to the eye as being nearly

white in color.

66. The principle of operation of white-light LED light sources was straightforward once blue-light LED chips were available. As described in Shimizu and elsewhere, LED chips convert electricity to light very efficiently, but they emit monochromatic light in a relatively narrow range. LED chips have long been known to emit red or green light. Technology for making LED chips that emit blue light was eventually commercially developed in the 1990s. But LED chips do not emit the broad spectrum of light that is perceived as white light.

67. Phosphors are used to convert the wavelength of light by absorbing light at one wavelength and emitting it at another. Because blue light is at the higher frequency (smaller wavelength) end of the visible light spectrum, it is also higher energy than other visible light. Thus, there are phosphors that will convert higher energy blue light to a lower energy complementary light like yellow light.



NASA, ESA, STScI (available at <https://perma.cc/QM4N-WPKS>)

68. The light output by a typical white-light LED light source is the sum of the yellow light emitted by the phosphors and the unabsorbed light emitted by the LED chip. Shimizu demonstrates this using a series of charts. Figures 19A-C

have been annotated below to indicate 440 nm (as specified in the claims of the '678 patent) and shade the visible blue light range above 440 nm.

69. Figure 19A shows the relative intensity of the yellow light emitted by the phosphors. Figure 19B shows the relative intensity of the blue light emitted by the blue light LED chip, which has a peak at 450 nm. Finally, Figure 19C shows the relative intensity of the white light that is the sum of the emitted blue and yellow light, reflecting the contribution at 450nm of the blue light emitted by the LED chip and not absorbed by the phosphors.

Fig.19A

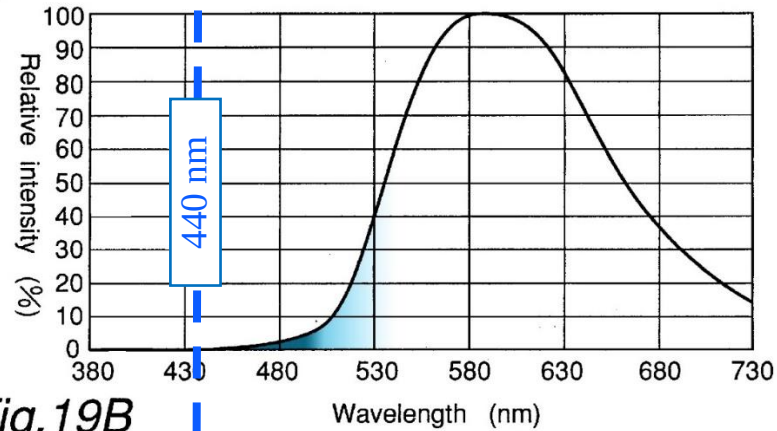


Fig.19B

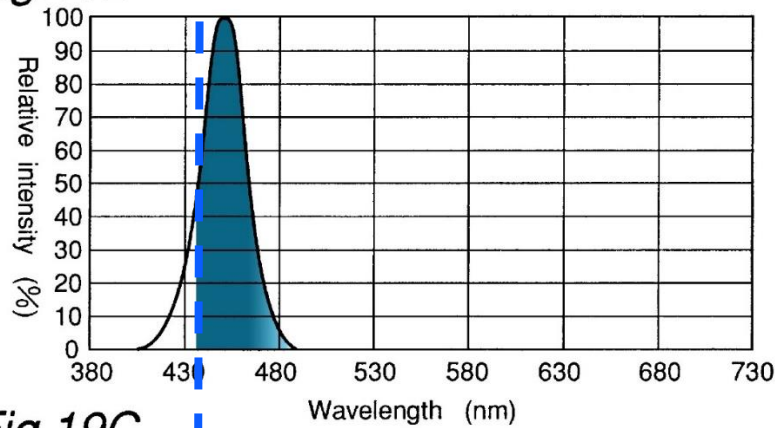
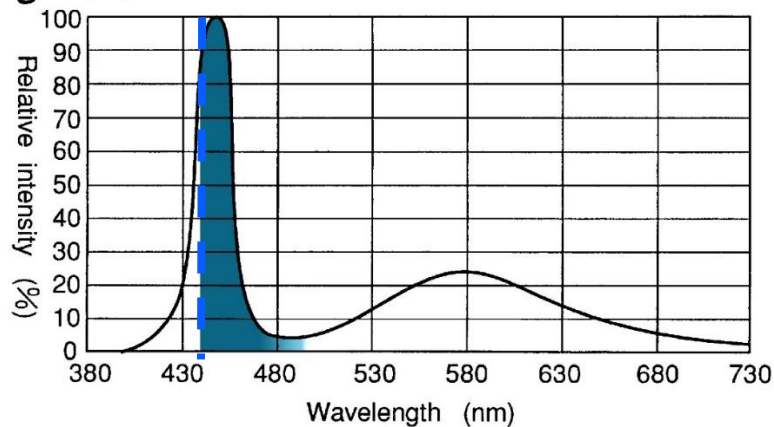


Fig.19C



C. White-light LED light sources were improved with a TiO₂-containing light diffusing layer

70. It was well-known to use a light diffusing layer, such as a layer containing TiO₂ particles, with LED light sources to diffuse light, as discussed

above and disclosed in numerous references, including those cited during prosecution. TiO_2 itself is a commodity chemical, the standard white pigment (“titanium white”), and the most important white pigment in the world.

71. Because the phosphors described above absorb blue light and emit yellow light, they will absorb ambient blue light and emit a small amount of yellow light even when the LED light source is off. This gives the phosphors a yellowish appearance. And that gives the white-light LED a yellowish color when powered off.

72. Once white-light LED light sources were developed, it was obvious to use a light diffusing layer containing TiO_2 particles to, among other things, make the white LED light sources appear whiter when turned off. This is reflected in the number of prior art references that did so, as discussed with respect to the asserted references below.

73. Indeed, data that the '678 patent presents without attribution can also be found in the prior art, because prior artists used the same data for the same purpose and properly attributed the data to DuPont, the TiO_2 particle manufacturer. DuPont had provided the copyrighted data with educational and marketing materials for its customers, customers like the prior artisans. Additionally, Dupont had sponsored and widely published scientific papers stretching back to the 1970's with detailed analysis in the 1990's explaining the physical mechanisms, light

diffusion/scattering, of the TiO_2 (Titania) particles making their form and purpose well known decades before the priority date of the '678 patent (EX1014, EX1015, EX1016, EX1017.) In these references and the Dupont marketing data (EX1012, EX1013), TiO_2 is interchangeably referred to as TiO_2 , Titania, and Titanium Oxide and the specific crystalline form of TiO_2 best suited for the scattering mechanism, rutile, was identified and known.

74. Accordingly, it was well-known to use a TiO_2 -containing light diffusion layer with a white light LED light source, as claimed by the '678 patent.

D. Summary of the '678 Patent

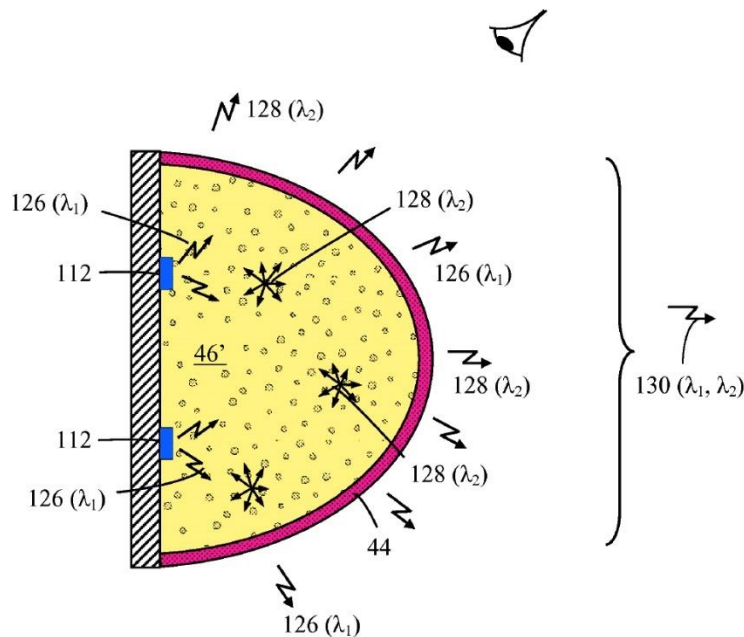


FIG. 18

75. The '678 patent is entitled "Wavelength Conversion Component with a Diffusing Layer." The disclosed wavelength conversion component with a diffusing layer is configured to be used with a blue-light LED and other components to create a white-light LED light source.

76. The '678 patent claims broadly cover a white-light LED light source with a light diffusing layer containing TiO₂ particles, e.g.:

1. A wavelength conversion component for a light emitting device comprising:
 - a wavelength conversion layer comprising particles of at least one photoluminescence material; and
 - a light diffusing layer comprising particles of a light scattering material,wherein the light diffusing layer improves an off-state white appearance of the wavelength conversion component;
wherein the wavelength conversion component is configured such that in operation a portion of excitation light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the light emitting device is emitted through the wavelength conversion component to contribute to a final visible emission product.

77. The addition of a "light diffusing layer" is the only claim requirement that is not admitted prior art. The others are all fundamental to any white-light LED light source made with a blue-light LED chip, as disclosed by, for example,

Shimizu. Shimizu is both cited in the '678 patent as well as incorporated by reference in Stokes.¹

78. The prior art Basin-2007 and Krummacher both disclose white-light LED light sources including a “light diffusing layer” containing TiO₂ particles.

E. Prosecution History of the '678 Patent

79. The '678 patent issued from U.S. Pat. Appl. No. 13/273,212. (EX1004.) It claims priority to U.S. Provisional Pat. Appl. Nos. 61/390,091, filed October 5, 2010, and 61/427,411, filed December 27, 2010.

80. During prosecution, the only prior art reference applied by the Examiner against the independent claims for the “light diffusing layer” was U.S. Pat. Pub. No. 2002/0180351 to McNulty. The applicants distinguished McNulty on the basis that it (1) was not configured like a white light LED light source (EX1004, pp.150-55), and (2) indeed, taught an ultraviolet (i.e., not visible light) LED chip unsuitable for a white-light LED light source (EX1004, pp.200-03).

81. With respect to the *first* distinction, the applicants amended the claims to require the configuration used by white-light LED light sources, which as discussed below, mix blue light emitted directly from a blue-light LED chip with

¹ U.S. Patent No. 5,998,925 (“Shimizu-APA,” EX1009) is cited by the '678 patent.

U.S. Patent No. 6,069,440 (EX1010) is incorporated by reference in Stokes.

yellow light emitted by phosphors which are excited by the blue light (and appear yellow when the light source is off). (EX1004, p.145.) The relevant requirements with respect to claim 1 are underlined once below. With respect to the ***second*** distinction, the applicants amended the claims to specifically require the blue light generated by a blue-light LED chip (as would be used in a white-light LED light source). (EX1004, p.194.) That amendment is underlined twice below.

1. A wavelength conversion component for a light emitting device comprising:
a wavelength conversion layer comprising particles of at least one photoluminescence material; and
a light diffusing layer comprising particles of a light scattering material,
wherein the light diffusing layer improves an off-state white appearance of the wavelength conversion component;
wherein the wavelength conversion component is configured such that in operation a portion of excitation light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the light emitting device is emitted through the wavelength conversion component to contribute to a final visible emission product.

82. The applicants convinced the Examiner that it would not have been obvious to use a light diffusing layer with a phosphor-converted white-light-emitting LEDs utilizing blue LEDs. (EX1004, p.1151 (citing pp.1053-57).) The

applicants never informed the Examiner that the use of a TiO₂-containing light diffusing layer with a white-light LED light source was disclosed in the prior art.

IX. OPINIONS ON CLAIM CONSTRUCTION

83. I understand that claim construction is considered an issue of law that will be resolved by the Board. This section explains my opinion regarding how a person having ordinary skill in the art would have understood the claim terms identified below after reviewing the '678 patent and file history.

84. As discussed above, the prosecution history of the '678 patent confirms that the claim term “blue light having a wavelength of greater than or equal to 440 nm generated by the light emitting device” was intended to encompass the blue light emitted by a blue-light LED chip and exclude the ultraviolet light emitted by a UV LED chip. (EX1004, p.194, 200-03.)

85. The specification of the '678 patent confirms that TiO₂ particles are light scattering particles within the meaning of the claims. (*E.g.*, EX1001, 8:19-21 (“The diffusing layer 44 comprises a uniform thickness layer of particles of a light diffractive material, preferably titanium dioxide (TiO₂).”).) *See also* EX1001, 6:28-31 (“Additionally the wavelength conversion component comprises a light diffusing layer comprising particles of a light diffractive material (also referred to herein as ‘light scattering’).”)

86. The specification also confirms that phosphor materials are photoluminescent materials within the meaning of the claims. (*E.g.*, EX1001, 1:36 (“photoluminescent materials (e.g., phosphor materials)”)).

X. SUMMARY OF INVALIDITY POSITIONS

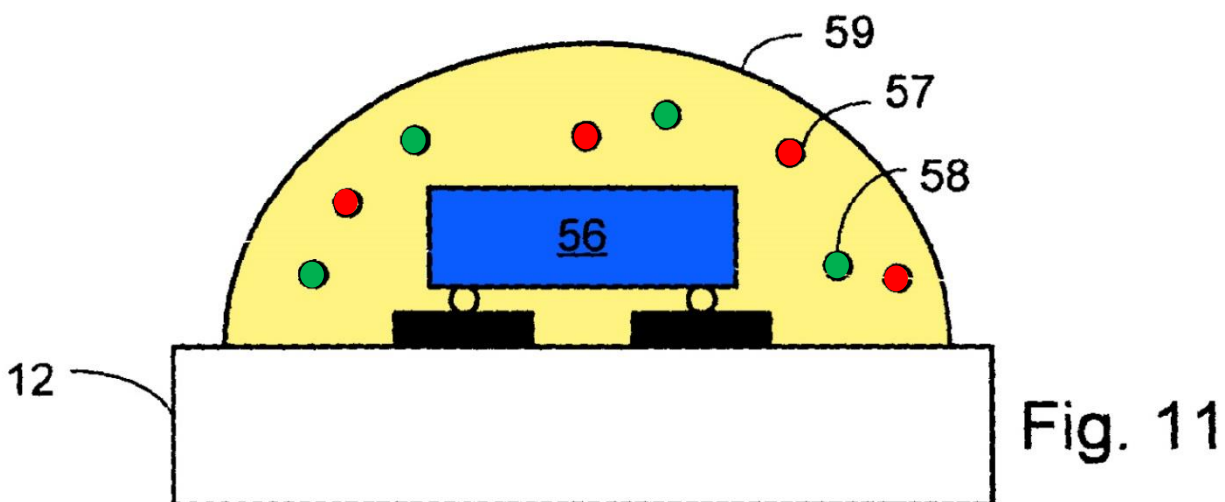
87. I understand that Petitioners are requesting review of claims 1-3, 6, 7, 9, 10, 16-21, 25, 26, and 29 of the '678 patent under the following grounds:

Ground	Claims	Description
1	1-3, 6, 7, 9, 10, 16-21, 25, and 26	Obvious over Basin-2007 in view of Basin-2005
2	19, 20, and 29	Obvious over Hussell in view of Basin-2007 and Van Woudenberg
3	1-3, 6, 10, 16, 19, 21, and 25	Obvious over Krummacher in view of Shimizu and Stokes
4	19, 20, and 29	Obvious over Hussell in view of Krummacher and Van Woudenberg

88. It is my opinion that the identified prior art renders the challenged claims obvious.

XI. PRIOR ART REFERENCES

A. Basin-2005 (Pub. No. US2007/0045761; EX1006)



89. U.S. Patent Publication No. US2007/0045761 entitled “Color Converted Light Emitting Diode” to Basin (“Basin-2005”) was filed on August 26, 2005 and published on March 1, 2007. (EX1006.) Basin-2005 is prior art under pre-AIA 35 U.S.C. § 102(b).

90. Basin-2005 discloses prior art LED light sources, including white-light LED light sources using blue-light LED chips. Figure 11 of Basin-2005, annotated above, shows a white-light LED light source consisting of “a blue LED [chip] 56” and “red and green phosphors 57, 58 ... infused in the encapsulant [silicone] 59 to create white light.” (EX1006, [0062].)

91. Basin-2005 was not before the Examiner during prosecution of the '678 patent.

B. Basin-2007 (Pub. No. US2009/0057699; EX1005)

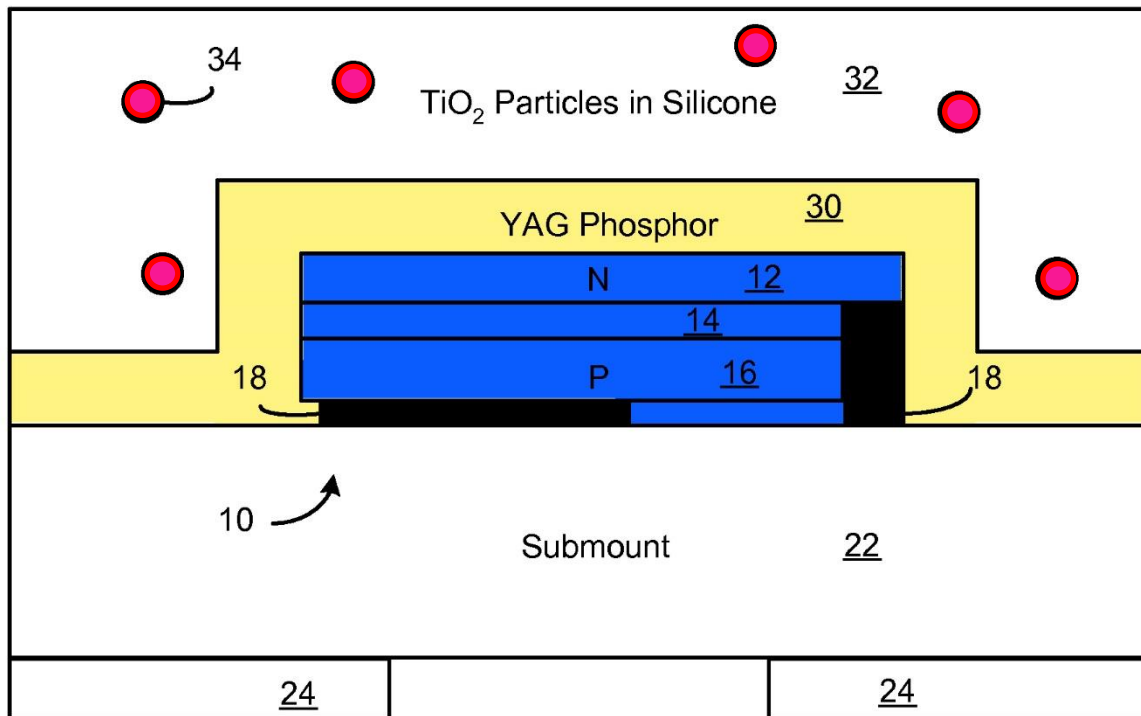


Fig. 2

92. U.S. Patent Publication No. US2009/0057699 entitled “LED with Particles in Encapsulant for Increased Light Extraction and Non-Yellow Off-State Color” also to Basin (“Basin-2007”) was filed on September 4, 2007 and published on March 5, 2009. (EX1005.) Basin-2007 is prior art under pre-AIA 35 U.S.C. § 102(b).

93. In just its title, Basin-2007 discloses the advancement claimed in the '678 patent. As shown in the annotated Figure 2 above, Basin-2007 discloses a blue light led chip (12, 14, 16), a phosphor-containing wavelength conversion layer (30), and a light diffusing layer containing TiO₂ particles (32).

94. Basin-2007 was not before the Examiner during prosecution of the '678 patent.

C. Krummacher (Pub. No. US2008/0079015; EX1007)

FIG 1

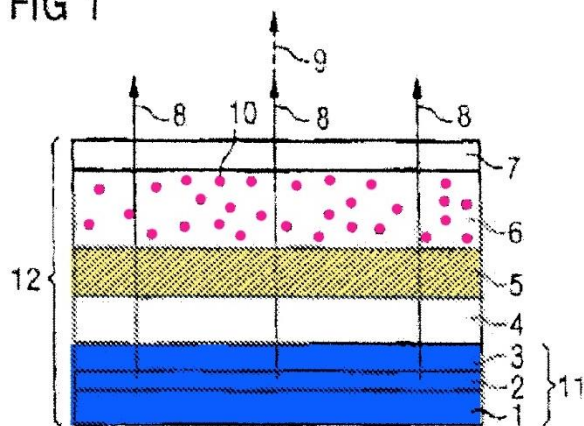
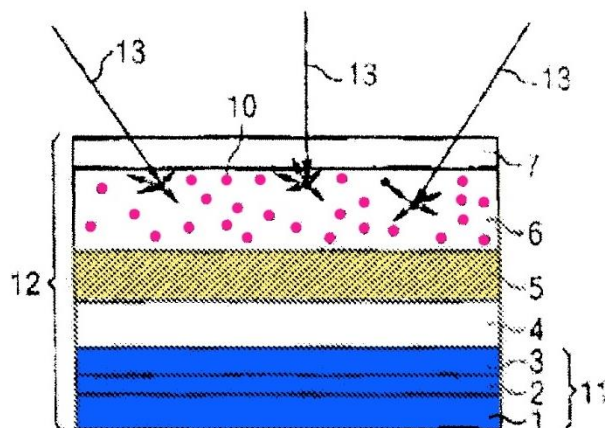


FIG 2



95. U.S. Patent Publication No. US 2008/0079015 A1 entitled “Optoelectronic Component Having a Luminescence Conversion Layer” to Krummacher was filed on September 18, 2007 and published on April 3, 2008. (EX1007.) Krummacher is prior art under pre-AIA 35 U.S.C. § 102(b).

96. As shown in the annotated figures above, Krummacher also discloses a white-light LED light source with a blue-light LED chip (11) with an encapsulant layer (4), a phosphor-containing wavelength conversion layer (5), a particle-containing light diffusing layer (6), followed by a cladding layer (7). Figure 1 shows the white-light LED light source in the ON state, where the blue light from the LED chip (11) combines with the yellow light from the phosphor layer (5) to create a white-light LED light source. Figure 2 shows that the light-diffusing layer

(6) (containing, for example, TiO_2 particles) obscures any yellow light from the phosphor layer (5) when the light source is in the OFF state.

97. Krummacher was not before the Examiner during prosecution of the '678 patent.

D. Stokes (Pat. No. 6,791,259; EX1008)

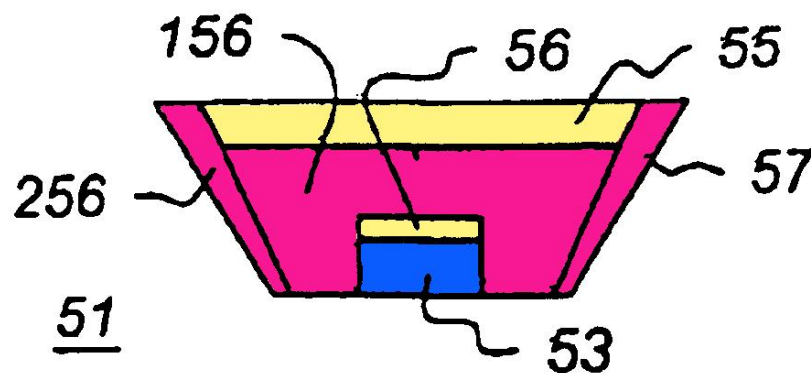


fig 7

98. U.S. Patent No. 6,791,259 entitled “Solid State Illumination System Containing a Light Emitting Diode, a Light Scattering Material and a Luminescent Material” to Stokes was filed on August 22, 2000 and issued on September 14, 2004. (EX1008.) Stokes is prior art under pre-AIA 35 U.S.C. § 102(b).

99. Stokes also discloses a white-light LED light source with light diffusing layers containing TiO_2 particles (56, 156, and 256 in the annotated image

above). Significantly the “prior art” Figure 6 of Stokes (shown below) is essentially the same as Figure 10 of the ’678 patent. Stokes attributes the data to DuPont, and the data relates to the relative scattering of different size TiO_2 particles on red, green, and blue light. (EX1008, 7:7-26, [56] (citing “DuPont Ti-Pure Titanium Dioxide Web Page,” visited Aug. 3, 2000).)

100. Stokes was not before the Examiner during prosecution of the ’678 patent. The applicants did not inform the Examiner that at least Figure 10 of the ’678 patent was in the prior art.

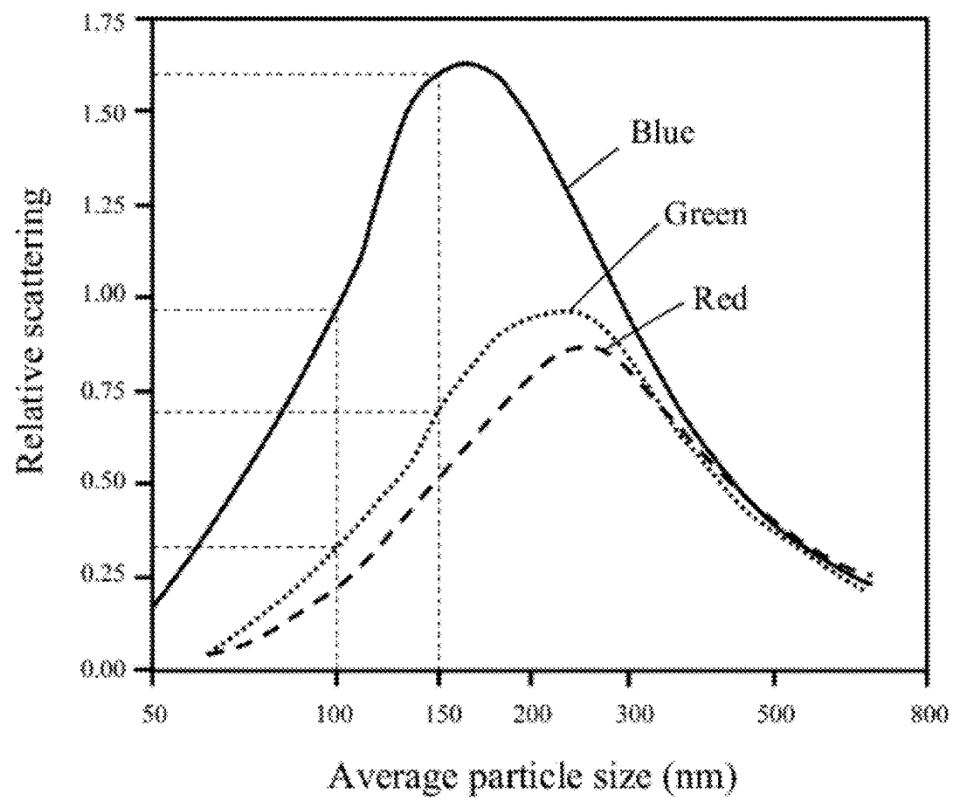


FIG. 10

'678 patent (EX1001).

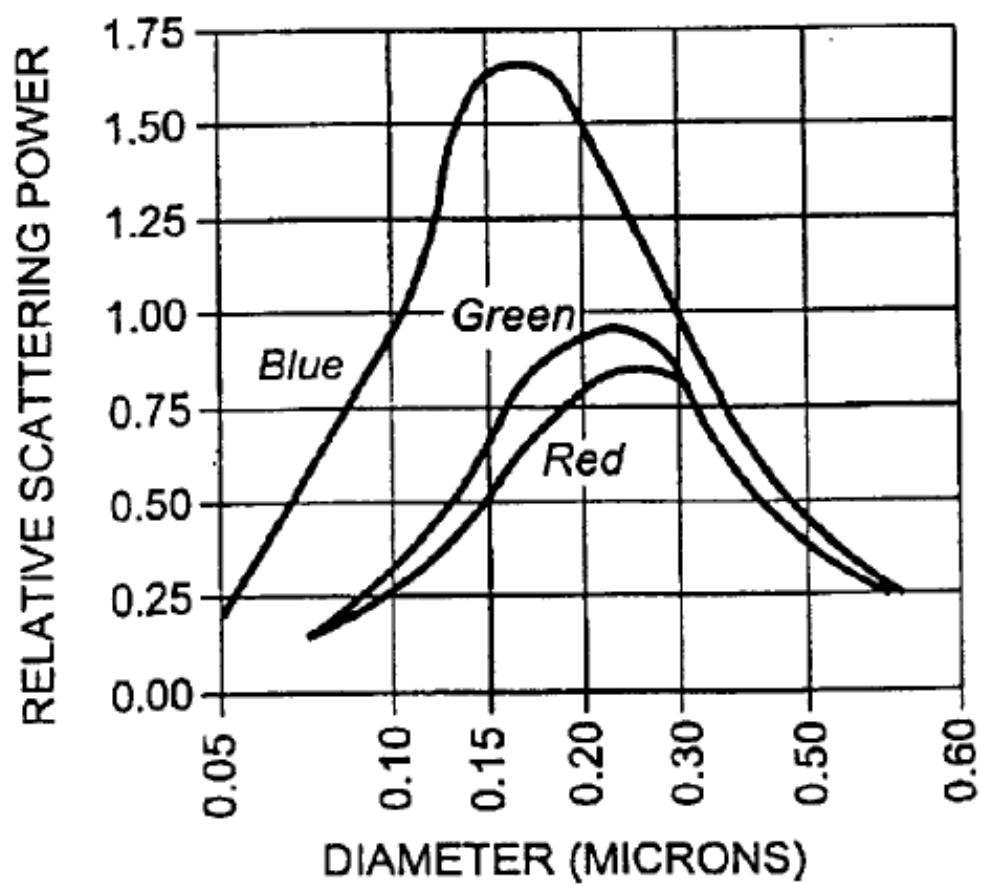
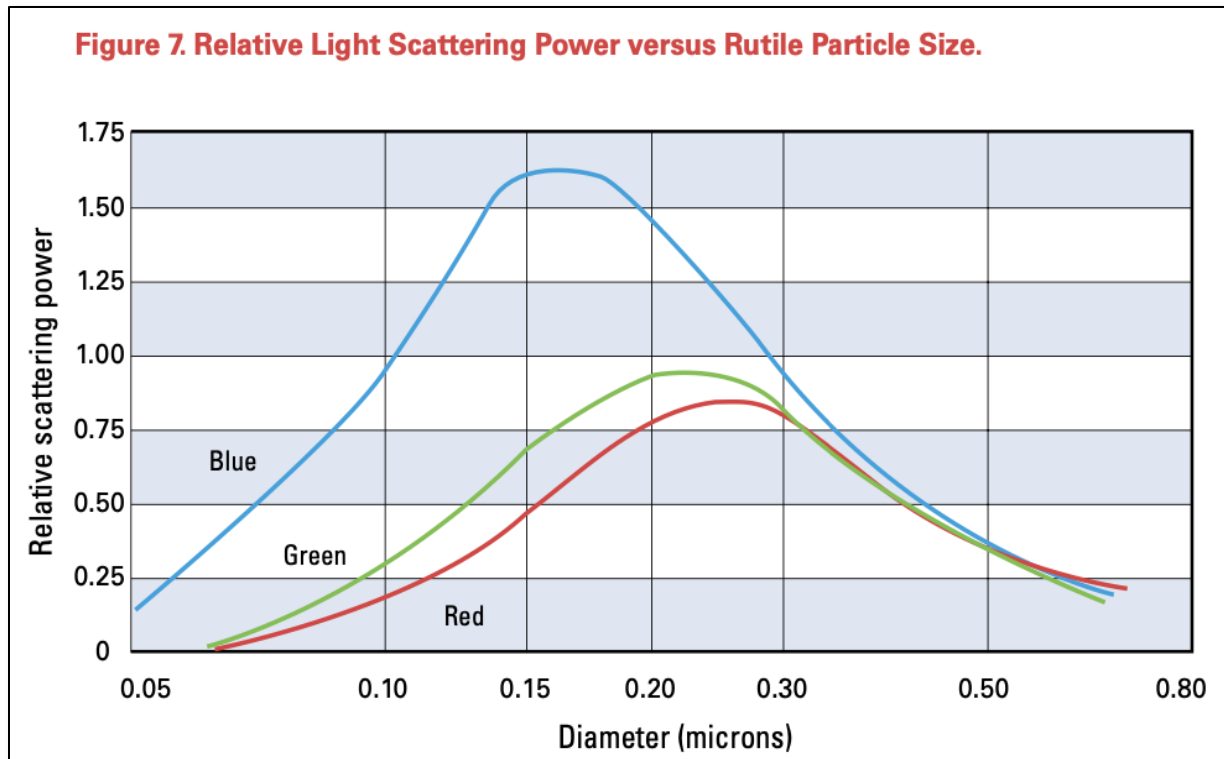


fig. 6
(PRIOR ART)

Stokes (EX1008).



DuPont™ Ti-Pure® titanium dioxide Brochure, Copyright 2007²(EX1013) at 8.

² As stated in the 2007 brochure, the curves shown in these figures are not based on experimental data but are theoretical: “Curves in Figure 7 derived from theoretical considerations in highly dilute systems show the relative scattering power of rutile TiO₂ for blue, green and red light as a function of particle size.” (EX1013, p.8.)

E. Shimizu (Pat. No. 6,069,440; EX1010) and Shimizu-APA (Pat. No. 5,998,925; EX1009)

Fig.1

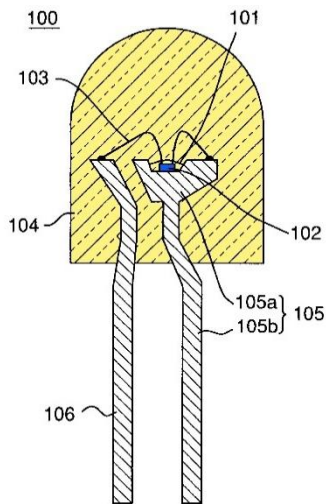
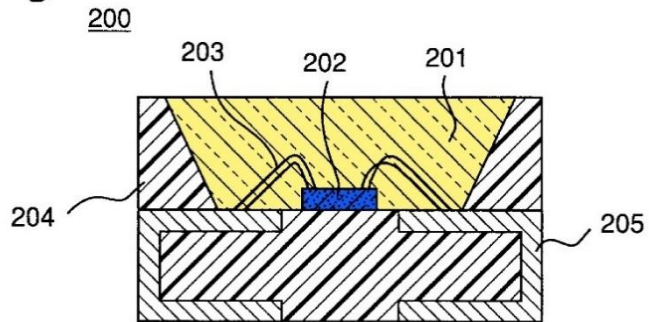


Fig.2



101. Both entitled “Light Emitting Device Having a Nitride Compound Semiconductor and a Phosphor Containing a Garnet Fluorescent Material,” U.S. Patents Nos. 5,998,925 (“Shimizu-APA”) and 6,069,440 (“Shimizu”) issued from divisional applications and share a common disclosure. Shimizu-APA is cited by the ’678 patent as admitted prior art. Shimizu is incorporated by reference into Stokes.

102. Shimizu discloses a prior art white-light LED light source. It includes a detailed discussion of the components of the white light emitted by a white light LED light source, as referenced above.

103. Shimizu is also anticipatory, as it discloses using a diffusing layer to improve the OFF-state color of a white-light LED light source, e.g.:

According to the present invention, adding the dispersant

and/or a coloration agent in the molding material has the effects of masking the color of the fluorescent material obscured and improving the color mixing performance. That is, the fluorescent material absorbs blue component of extraneous light and emits light thereby to give such an appearance as though colored in yellow. However, the **dispersant** contained in the molding material gives **milky white color** to the molding material and the coloration agent renders a desired color. **Thus the color of the fluorescent material will not be recognized by the observer.**

(EX1010, 17:35-45.)

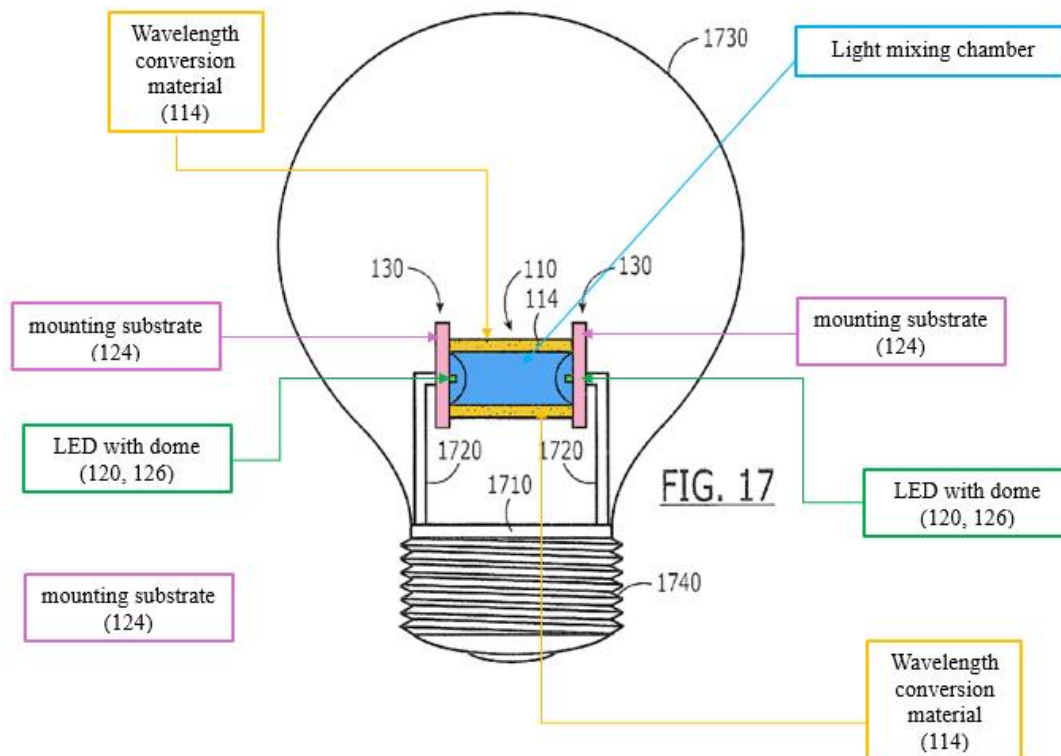
104. The applicants did not inform the Examiner that Shimizu disclosed a white-light LED light source with the claimed light diffusing layer.

F. Hussell (Pub. No. US2010/0124243; EX1021)

105. U.S. Patent Publication No. US2010/0124243 to Hussell et al (“Hussell”), filed on November 18, 2008 and published on May 20, 2010, is prior art under at least 35 U.S.C. §102(b).

106. Hussell discloses a “semiconductor light emitting apparatus” that leverages a “wavelength conversion tube” to obtain “high efficiency white light production.” (EX1021, Abstract, ¶[0038].) In one embodiment (depicted in Figure 17 below), the wavelength conversion tube is “analogized to the filament of a conventional incandescent lamp” wherein the “combination of the elongated

hollow wavelength conversion tube” and “packaged semiconductor devices” provide “a filament for a drop-in replacement for an incandescent bulb.” (EX1021, ¶[0052].)



Hussell, Annotated Figure 17

XII. GROUNDS OF OBVIOUSNESS

[GROUND 1] Claims 1-3, 6, 7, 9, 10, 16-21, 25, and 26 are rendered obvious by Basin-2007 and Basin-2005

107. Basin-2007 discloses a white light LED light source with a blue-light LED chip, a phosphor-containing wavelength conversion layer (30), and a TiO_2 -particle-containing light diffusion layer (32), thus rendering obvious claims 1-3, 6, 7, 9, 10, 16-21, 25, and 26 of the '678 patent. A person skilled in the art would

have been motivated to look to the teachings in Basin-2005 to understand the wavelength emitted by the LED chip in Basin-2007 due to the structural similarity between the disclosed LEDs. (*Compare, e.g., EX1005, Fig. 2 with EX1006, Fig. 5.*) And the information obtained from Basin-2005 is no more than the simple substitution of one known element for another to obtain predictable results.

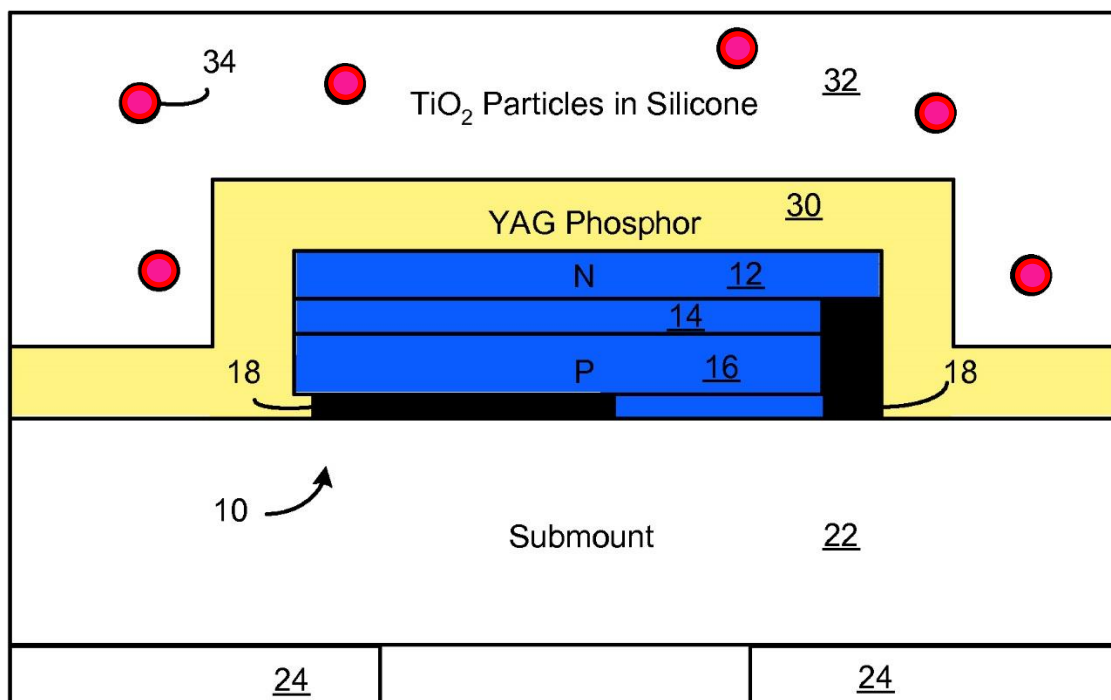


Fig. 2

Independent Claim 1: Wavelength Conversion Component

108. Claim 1 of the '678 patent reads as follows:

[1pre] A wavelength conversion component for a light emitting device comprising:

[1a] a wavelength conversion layer comprising particles of at least one photoluminescence material; and

- [1b] a light diffusing layer comprising particles of a light scattering material,
- [1c] wherein the light diffusing layer improves an off-state white appearance of the wavelength conversion component;
- [1d] wherein the wavelength conversion component is configured such that in operation a portion of excitation light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the light emitting device is emitted through the wavelength conversion component to contribute to a final visible emission product.

109. Basin-2007 discloses each of these claim requirements as detailed below.

[1pre] A wavelength conversion component for a light emitting device

110. Basin-2007 discloses a wavelength conversion component. Basin-2007 discloses “a conventional white light LED [light source] encapsulated in silicone” including a blue light LED chip. (EX1005, ¶[0021].) The blue light LED chip is “covered by a layer of yttrium aluminium oxide garnet (YAG) phosphor that emits a yellow-green light when energized by the blue light.” (*Id.*, ¶[0003].) In reference to Fig. 2, Basin-2007 discloses that the wavelength conversion component comprises “a phosphor layer 30 is formed over the top of the LED for wavelength-converting the blue light emitted from the active layer 14.” (*Id.*, ¶[0027].)

111. Accordingly, it is my opinion that Basin-2007 discloses a light emitting device with a wavelength conversion component.

[1a] a wavelength conversion layer comprising particles of at least one photoluminescence material

112. Basin-2007 discloses the inclusion of a wavelength conversion layer comprising particles of at least one photoluminescence material. It is shown, for example, as layer 30 in the annotated Figure 2 above. Consistent with other white-light LED light sources, Basin-2007 discloses covering the blue-light LED with “a layer of yttrium aluminum oxide garnet (YAG) phosphor [i.e. photoluminescent material] that emits a yellow-green light when energized by the blue light.” (*Id.*, ¶[0003]) That is “a phosphor layer 30 is formed over the top of the LED for wavelength-converting the blue light emitted from the active layer 14.” (*Id.*, ¶[0027].) “The phosphor layer 30 may be phosphor particles in a transparent or translucent binder, which may be organic or inorganic, or may be sintered phosphor particles.” (*Id.*)

113. Accordingly, it is my opinion that Basin-2007 discloses a wavelength conversion layer comprising particles of at least one photoluminescence material.

[1b] a light diffusing layer comprising particles of a light scattering material

114. Basin-2007 discloses the inclusion of a light diffusing layer comprising particles of a light scattering material. It is shown, for example, as layer 32 in the annotated Figure 2 above. That is, Basin-2007 discloses that “TiO₂

particles are mixed with the encapsulant.” (*Id.*, ¶¶[0005, 0013, 0017, 0019, 0031, 0042].) Basin-2007 further discloses that “the TiO₂ particles scatter the light from the LED, which helps to mix the light output to create a more uniform brightness and color over the viewing field.” (*Id.*, ¶[0037].)

115. Accordingly, it is my opinion that Basin-2007 discloses a light diffusing layer comprising particles of a light scattering material.

[1c] wherein the light diffusing layer improves an off-state white appearance of the wavelength conversion component

116. Basin-2007 discloses that the light diffusing layer improves an off-state white appearance of the wavelength conversion component. Indeed, the title of Basin-2007 is “LED with Particles in Encapsulant for Increased Light Extraction and Non-Yellow Off-State Color.” Basin-2007 discloses that “[i]f the LED has a yellowish YAG phosphor coating, the white [TiO₂] granules in the encapsulant make the LED appear whiter when the LED is in an off state, which is a more pleasing color when the LED is used as a white light flash in small cameras.” (*Id.*, (57).)

117. Basin-2007 discloses the motivation for using a layer including TiO₂ particles as thus: “The YAG phosphor coating on the LED appears yellow-green under white ambient light when the LED is off. Such a yellow-green color is generally not attractive and typically does not match well with the appearance of the camera. It is desirable to somehow eliminate the yellow-green color of the

[LED] flash in its off state.” (*Id.*, ¶[0004].) The solution is straightforward: “Since the inert material (e.g., TiO₂, or ZrO₂) is white, the appearance of the LED with a YAG phosphor coating appears much whiter when the LED is off, which is more pleasing than the yellow-green color of the YAG phosphor.” (*Id.*, ¶[0010].)

118. Accordingly, it is my opinion that Basin-2007 discloses the light diffusing layer improves an off-state white appearance of the wavelength conversion component.

[1d] wherein the wavelength conversion component is configured such that in operation a portion of excitation light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the light emitting device is emitted through the wavelength conversion component to contribute to a final visible emission product

119. Basin-2007 discloses that a portion of excitation light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the light emitting device is emitted through the wavelength conversion component to contribute to the final visible emission product.

120. That is, for example, Basin-2007 discloses GaN-based LEDs (*Id.*, ¶[0002]) that “[t]he light emitted by the phosphor layer 30, when mixed with blue light, creates white light or another desired color. In the example, the phosphor is a yttrium aluminum oxide garnet (YAG) phosphor that produces yellow light (Y+B=white).” (*Id.*, [0027].) In other words, the blue light contributes to the final emission product.

121. Although Basin-2007 does not specify the wavelength of blue light emitted by its LED chip, a POSA would have understood it to include blue light with a wavelength greater than 440 nm as such devices are admitted in the '678 patent itself as being available off-the-shelf. Basin-2007 discloses that it is based on “a conventional white light LED” light source including an example LED chip that “generates blue light.” (*Id.*, ¶[0021-22].) Consistent with the state of the art as discussed above, including Shimizu, a POSA would understand that the blue light LEDs emitted from conventional white light LED light sources typically had wavelengths greater than 440 nm. Indeed, that is consistent with the wavelengths disclosed throughout the prior art for the blue light emitted by blue light LED chips. (See EX1010, figs.; EX1010, 23:43, 27:4-5, 28:55, 25:24-25, 29:45 (peaks at 450, 460, or 470nm); EX1006, ¶[0030] (“It is assumed the LEDs emit a blue light in the range of 420-490 nm.”); EX1008, 4:37-40 (420-480nm), 6:62-67 (peaks of 450nm or 480nm).) It is also consistent with the prosecution of the '678 patent where this requirement was added for the purpose of distinguishing blue light from UV light. (EX1004, pp.194, 200-03.)

122. Moreover, a white light LED light source containing a blue light LED chip generating “blue light having a wavelength of greater than or equal to 440 nm” would have been obvious in view of Basin-2005 in any case. Basin-2005 discloses a white light LED light source consistent with claims 1 and 19 of

the '678 patent. Basin-2005 further discloses, for example, that “[i]t is assumed the LEDs emit a blue light in the range of 420-490 nm.” (EX1006, ¶[0030].)

123. A POSA would have been motivated to use a white light LED light source disclosed by Basin-2005 as the “conventional white light LED” called for by Basin-2007. This is at least due to the structural similarity between the LEDs in Basin-2007 and Basin-2005. (*Compare, e.g.,* EX1005, Fig. 2 *with* EX1006, Fig. 5; EX1002, ¶123.) Having looked from Basin-2007 to Basin-2005, a POSA would have had a reasonable expectation of success, because Basin-2005 teaches that its white-light LED light source is “relatively easy to implement and consistently produces the desired white light temperature.” (EX1006, ¶[0006].)

124. Accordingly, it is my opinion that Basin-2007 discloses or suggests the wavelength conversion component is configured such that in operation a portion of excitation light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the light emitting device is emitted through the wavelength conversion component to contribute to a final visible emission product.

125. It is my opinion that Basin-2007 in view of Basin-2005 thus teaches all of the elements of claim 1 and renders claim 1 obvious.

Claim 2: Layers in Direct Contact

126. Claim 2 requires “[t]he component of claim 1, wherein the wavelength conversion layer and the light diffusing layer are in direct contact with each other.”

127. As discussed above, Basin-2007 discloses or renders obvious claim 1. Basin-2007 further discloses that the wavelength conversion layer and the light diffusing layer are in direct contact with each other. As shown in Figure 2 (annotated here), the wavelength conversion layer 30 containing “YAG Phosphor” and the light diffusing layer 32 containing “TiO₂ Particles [34] in Silicone” are in direct contact with each other.

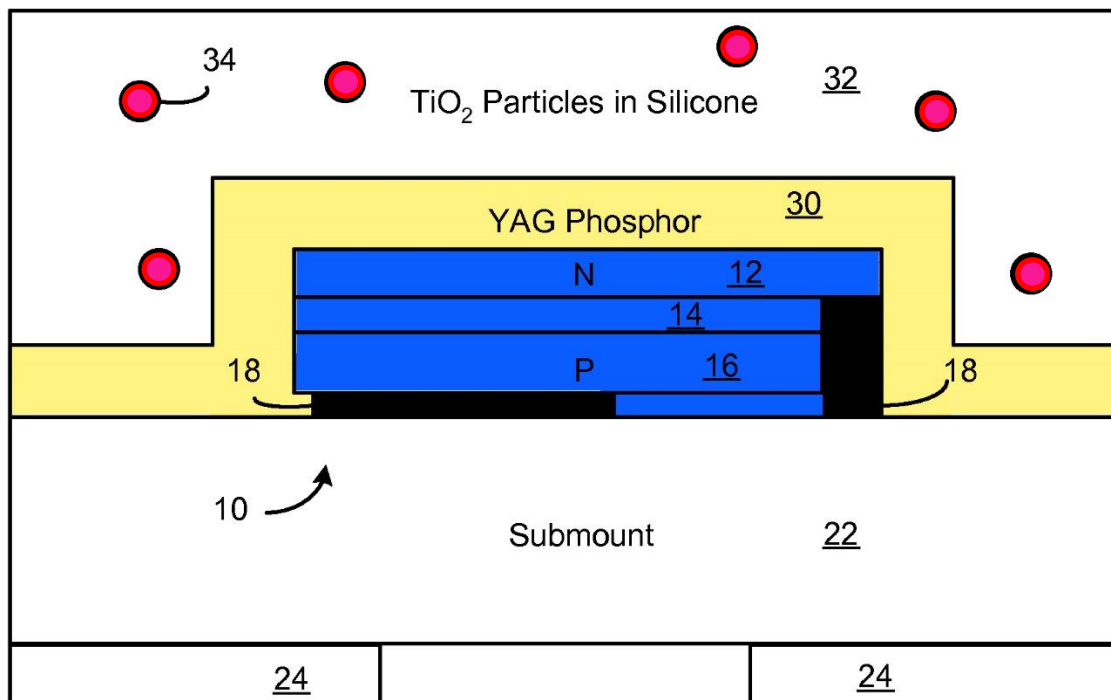


Fig. 2

128. That is, as described in Basin-2007, “silicone encapsulant 32” is “formed over the LED structure” immediately after the phosphor layer. (*Id.*, ¶[0027].)

129. It is my opinion that Basin-2007 thus teaches all of the elements of claim 2 and renders claim 2 obvious as a whole.

Claim 3: Layers in Light Transmissive Binder

130. Claim 3 requires “[t]he component of claim 1, wherein the wavelength conversion layer comprises a mixture of the at least one phosphor material and a light transmissive binder and the light diffusing layer comprises a mixture of the light scattering material and the light transmissive binder.”

131. As discussed above, Basin-2007 renders claim 1 obvious. Basin-2007 further discloses the wavelength conversion layer and the light diffusing layer both being mixtures including a light transmissive binder, such as silicone. As shown in Figure 2 (annotated above), the light diffusing layer 32 is “TiO₂ Particles in Silicone.” Basin-2007 further discloses the “phosphor layer 30 may be phosphor particles in a transparent or translucent binder, which may be organic or inorganic, or may be sintered phosphor particles.” (EX1005, ¶[0027].) Silicone is an example of an inorganic transparent binder.

132. Accordingly, Basin-2007 discloses that both the light diffusing layer and the wavelength converting layer may be made of a mixture with a light transmissive binder such as silicone.

133. Although Basin-2007 does not expressly specify that both layers use the same light transmissive binder, a POSA would have understood Basin-2007 to disclose both layers being a silicone binder. For one thing, silicone is the only transparent binder expressly disclosed by Basin-2007. It is also pervasive as a binder and encapsulant throughout the state of the art, as shown by the cited references. A POSA would also understand that using a single transmissive binder would result in the layers having similar refractive indexes and thus bend light less at their interface and have less reflection loss. (See EX1005, ¶[0002] (“By encapsulating the LED in a transparent material, such as silicone ($n=1.4-1.76$), having an intermediate index of refraction, the light extraction is significantly increased.”).) As Basin-2007 discloses, it may be undesirable to change the shape of the LED emission. (See *id.*, ¶[0011] (“...the encapsulant is formed to have flat surface so as not to significantly affect the shape of the LED emission ...”).)

134. Basin-2007 further discloses the “phosphor layer 30 may be phosphor particles in a transparent or translucent binder, which may be organic or inorganic, or may be sintered phosphor particles.” (EX1005, ¶[0027].) Moreover, a wavelength converting phosphor layer of silicone would have been obvious in

view of Basin-2005. Basin-2005 discloses, for example, a wavelength converting layer made by “mixing the phosphors in a bonding medium (e.g., silicone) and depositing the mixture on the blue LED.” (EX1006, [0002].)

135. A POSA would have been motivated to use the silicone binder disclosed by Basin-2005 with the disclosure of Basin-2007, because one would have looked to Basin-2005 for details of the conventional white light LED light source used in Basin-2007. And a POSA would have had a reasonable expectation of success in doing so, because they would simply be using the binder disclosed in Basin-2005 as directed by Basin-2007. In other words, not only does Basin-2007 suggest the use of an LED with a binder like that disclosed in Basin-2005, to do so would have been the simple substitution of one known element for another to obtain predictable results.

136. It is my opinion that Basin-2007 thus teaches all of the elements of claim 3 and renders claim 3 obvious as a whole.

Claim 6: Light Transmissive Binder is Silicone

137. Claim 6 requires “[t]he component of claim 3, wherein the light transmissive binder comprises a curable liquid polymer selected from the group consisting of: a polymer resin, a monomer resin, an acrylic, an epoxy, a silicone and a fluorinated polymer.”

138. As discussed above, Basin-2007 discloses or renders obvious claim 3. As also discussed above with respect to claim 3, Basin-2007 particularly discloses silicone as a light transmissive binder. (*See, e.g.*, EX1005, ¶[0002] (“By encapsulating the LED in a transparent material, such as silicone ($n=1.4-1.76$), having an intermediate index of refraction, the light extraction is significantly increased.”)).

139. Moreover, Basin-2007 further discloses the “phosphor layer 30 may be phosphor particles in a transparent or translucent binder, which may be organic or inorganic, or may be sintered phosphor particles.” (EX1005, ¶[0027].) So a wavelength converting phosphor layer of silicone would have been obvious in view of Basin-2005. Basin-2005 discloses, for example, a wavelength converting layer made by “mixing the phosphors in a bonding medium (e.g., silicone) and depositing the mixture on the blue LED.” (EX1006, [0002].)

140. A POSA would have been motivated to use the silicone binder disclosed by Basin-2005 with the disclosure of Basin-2007, because one would have looked to Basin-2005 for details of the conventional white light LED light source used in Basin-2007. And a POSA would have had a reasonable expectation of success in doing so, because they would simply be using the binder disclosed in Basin-2005 as directed by Basin-2007. In other words, not only does Basin-2007 suggest the use of an LED with a binder like that disclosed in Basin-2005, to do so

would have been the simple substitution of one known element for another to obtain predictable results.

141. It is my opinion that Basin-2007 thus teaches all of the elements of claim 6 and renders claim 6 obvious as a whole.

Claim 7: Weight Loading of Light Scattering Material

142. Claim 7 depends from claim 3 and includes the limitation “wherein the weight loading of light scattering material to binder selected from the group consisting of: 7% to 35% and 10% to 20%.”

143. Basin-2007 discloses or renders obvious this limitation. For example, Basin discloses that “[t]he optimum quantity of TiO_2 may vary anywhere between 1-10% of the weight of the silicone depending on the characteristics of the LED structure.” (EX1005, [¶0031])

144. It is my opinion that Basin-2007 thus teaches all of the elements of claim 7 and renders claim 7 obvious as a whole.

Claim 9: Deposition Methods

145. Claim 9 depends from claim 1 and includes the limitation “wherein the wavelength conversion and light diffusing layers are deposited using a method selected from the group consisting of: screen printing, slot die coating, spin coating, roller coating, drawdown coating and doctor blading.”

146. Basin-2007 discloses or renders obvious this limitation. For example, Basin teaches that “[t]he phosphor layer 30 may be spray deposited, spun-on, thin-film deposited by electrophoresis, preformed as a ceramic plate and affixed to the top of the LED layers, or formed using any other technique.” (EX1005, ¶0027)

147. It is my opinion that Basin-2007 thus teaches all of the elements of claim 9 and renders claim 9 obvious as a whole.

Claim 10: Light Scattering Material is TiO₂

148. Claim 10 requires “[t]he component of claim 1, wherein the light scattering material is selected from the group consisting of: titanium dioxide, barium sulfate, magnesium oxide, silicon dioxide and aluminum oxide.”

149. As discussed above, Basin-2007 discloses or renders obvious claim 1. As also discussed above with respect to the light diffusing layer requirement of claim 1, Basin-2007 discloses TiO₂ as a light scattering material. (See, e.g., EX1005, ¶0005] (“In one embodiment, granules of TiOx, ZrOx, or other white non-phosphor inert material are mixed with the substantially transparent encapsulant for LEDs. One suitable encapsulant is silicone. It has been discovered by the Applicants that sub-micron size particles of the inert material, such as TiO₂, in the encapsulant increase the brightness...”) and EX1005 ¶0037] (“It is believed that the TiO₂, particles scatter the light from the LED, which helps to mix

the light output to create a more uniform brightness and color over the viewing field.”).

150. It is my opinion that Basin-2007 thus teaches all of the elements of claim 10 and renders claim 10 obvious as a whole.

Claim 16: Planar Shapes

151. Claim 16 requires “[t]he component of claim 1 in which the wavelength conversion layer and the light diffusing layer comprises planar shapes.”

152. As discussed above, Basin-2007 discloses or renders obvious claim 1. As in Figure 2 above, Basin-2007 discloses a wavelength conversion layer and light diffusing layers that comprise planar (i.e., flat) shapes, because they are flat layers. Indeed, Basin-2007 teaches “the encapsulant is formed to have a flat surface so as not to significantly affect the shape of the LED emission (i.e., the encapsulant does not form a lens).” (EX1005, ¶[0011].)

153. It is my opinion that Basin-2007 thus teaches all of the elements of claim 16 and renders claim 16 obvious as a whole.

Claim 17: Dome or Elongated Dome Shaped Light Diffusing Layer

154. Claim 17 depends from claim 1 and requires that “the light diffusing layer comprises a dome or elongated dome shape.”

155. Basin-2007 discloses or renders obvious this limitation. Basin-2007 discloses that “the silicone encapsulant may be molded into a lens to shape the light emission pattern.” (EX1005, ¶[0011].) Basin-2007 discloses dome-shaped light diffusing layers. (EX1005, Figs. 5-10; *see also id.* ¶[0040] (disclosing “hemispherical” light diffusing layer).)

156. Basin-2007 in view of Basin-2005 thus teaches all of the elements of claim 17 and renders claim 17 obvious as a whole.

Claim 18: Wavelength Converting Layer Beneath the Dome

157. Claim 18 depends from claim 17 and further requires that “the wavelength conversion layer fills a volume formed beneath the dome or elongated dome shapes.”

158. Basin-2007 discloses or renders obvious this limitation. As shown in Figure 2, the wavelength conversion layer in Basin-2007 is depicted as being directly beneath the light diffusing layer. Accordingly, a POSA would understand that in the embodiment disclosed in Basin-2007 where the silicone encapsulant is “molded into a lens to shape the light emission pattern” (EX1005, ¶[0011]), the dome-shaped lens created by the encapsulant creates a volume over the LED chip wherein the wavelength conversion layer fills a volume formed beneath the dome.

159. Basin-2007 in view of Basin-2005 thus teaches all of the elements of claim 16 and renders claim 16 obvious as a whole.

Independent Claim 19: Light Emitting Device

160. Claim 19 of the '678 patent reads as follows:

19. A light emitting device comprising:
at least one solid-state light emitter operable to generate
excitation light; and
a wavelength conversion component comprising:
a wavelength conversion layer excitable by the excitation
light, wherein the wavelength conversion layer comprises
particles of at least one photoluminescence material; and
a light diffusing layer comprising particles of a light
scattering material,
wherein the light diffusing layer improves an OFF state
white appearance of the wavelength conversion
component;
wherein the wavelength conversion component is
configured such that in operation a portion of light
comprising blue light having a wavelength of greater
than or equal to 440 nm generated by the at least one
solid-state light emitter is emitted through the wavelength
conversion component to contribute to a final visible
emission product.

161. Claim 19 is essentially identical to claim 1 except that claim 19 also encompasses the “solid-state light emitter operable to generate excitation light,” or LED chip. As discussed in detail above with respect to claim 1, Basin-2007 discloses each of these claim requirements as arranged in the claim, including the

LED chip. (See also EX1005, ¶[0001] (“This invention relates to light emitting diodes (LEDs)...”).

162. It is my opinion that Basin-2007 thus teaches all of the elements of claim 19 and renders claim 19 obvious as a whole.

Claim 20: Applications for the Light Emitting Device

163. Claim 20 requires “[t]he device of claim 19, wherein the light emitting device is selected from the group consisting of . . . stage lighting, movie lighting, street lights, flood lights . . . and signs.

164. Basin-2007 discloses that “adding the TiO_2 to the encapsulant also improves the color temperature uniformity across the package. This is especially important when optics are use[sic] that project an enlarged image of the LED, such as with a flashlight or projector.” (EX1005, [¶0009].) A POSA would understand that a flashlight is a type of flood light and that a projector can be used as in stage lighting, movie lighting, street lights and signs.

165. Basin-2007 in view of Basin-2005 thus teaches all of the elements of claim 20 and renders claim 20 obvious as a whole.

Claim 21: Improved Off-State White Appearance

166. Claim 21 requires “[t]he device of claim 19 in which the light scattering material within the light diffusing layer corresponds to an average

particle size that improves the OFF state white appearance of the wavelength conversion component.”

167. As discussed above, Basin-2007 discloses or renders obvious claim 19. And as discussed in detail with respect to requirement [1c] of claim 1, Basin-2007 further discloses that the light diffusing layer improves an off-state white appearance. Given that Basin-2007 discloses the light diffusing layer improves an off-state white appearance, the light diffusing layer has “an average particle size that improves the OFF state white appearance” as required by claim 21. In any case, Basin-2007 also provides detailed information regarding preferred particle sizes and weight percentages of TiO_2 with respect to off state white appearance and light output. (EX1005, ¶¶[0029-36].) Accordingly, Basin-2007 discloses the light diffusing layer corresponds to an average particle size that improves an off-state white appearance of the wavelength conversion component.

168. It is my opinion that Basin-2007 thus teaches all of the elements of claim 21 and renders claim 21 obvious as a whole.

Claim 25: Planar Shapes

169. Claim 25 requires “[t]he device of claim 19 in which the wavelength conversion layer and the light diffusing layer comprises planar shapes.”

170. As discussed above, Basin-2007 discloses or renders obvious claim 19. And as discussed in detail with respect to claim 16, Basin-2007 further

discloses that the wavelength conversion layer and the light diffusing layer comprises planar shapes.

171. It is my opinion that Basin-2007 thus teaches all of the elements of claim 25 and renders claim 25 obvious as a whole.

Claim 26: Dome Shaped Light Diffusing Layer

172. Claim 26 requires “[t]he device of claim 19 in which the light diffusing layer comprises a dome or elongated dome shape.”

173. As discussed above, Basin-2007 discloses or renders obvious claim 19. And as discussed in detail with respect to claim 17, Basin-2007 further discloses that the light diffusing layer comprises a dome or elongated dome shape.

174. Basin-2007 in view of Basin-2005 thus teaches all of the elements of claim 26 and renders claim 26 obvious as a whole.

[GROUND 2] Claims 19, 20, and 29 are rendered obvious by Hussell, Basin-2007, and Van Woudenberg

175. As discussed above, Ground 1 renders obvious independent claims 1 and 19 of the '678 patent. Ground 2 further includes the teaching of “light bulb” type LED emitters by Hussell. As discussed above, the prior art discloses conventional white-light LED light sources with light diffusing layers as required by the claims. Claims 20 and 29 further require that the white light LED light source be incorporated into a device such as a light bulb, specifically:

20. The device of claim 19, wherein the light emitting device is selected from the group consisting of downlights, lightbulbs, linear lamps, lanterns, wall lamps, pendant lamps, chandeliers, recessed lights, track lights, accent lights, stage lighting, movie lighting, street lights, flood lights, beacon lights, security lights, traffic lights, headlamps, taillights, and signs.

...

29. A light bulb comprising:

a connector base configured to be inserted in a socket to form an electrical connection for the light bulb;

a body comprising one or more solid-state light emitters;

a wavelength conversion component having a three dimensional shape that is configured to enclose the one or more solid-state light emitters and to in part at least define a light mixing chamber,

wherein the wavelength conversion component comprises a wavelength conversion layer comprising particles of at least one photoluminescence material and a light diffusing layer comprising particles of a light scattering material,

wherein the light diffusing layer improves an off-state white appearance of the wavelength conversion component;

wherein the wavelength conversion component is configured such that in operation a portion of light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the one or more solid-state light emitters is emitted through the wavelength conversion component to contribute to a final visible emission product.

176. Hussell discloses every feature covered by claims 20 and 29 except Hussell does not explicitly disclose (i) a light diffusing layer that improves an off-state white appearance of the wavelength conversion component and (ii) that the wavelength of blue light emitted by the semiconductor light emitting device is greater than or equal to 440 nm. Hussell discloses a light bulb containing LED “filaments” which it also refers to as “wavelength conversion tubes.” (EX1011, ¶[0052].) These filaments have YAG phosphor located on the outer surface of the tube to convert blue light. But such YAG phosphors – the same phosphors disclosed in Basin-2007, Shimizu and Krummacher – appear yellow in the off-state. As disclosed in Basin-2007 (and other references discussed herein), such yellow appearance is undesirable. A POSA would have thus been motivated to avoid such an appearance and would find success doing so by coating the filaments in Hussell with a light diffusing layer as taught in Basin-2007. And Van Woudenberg discloses the wavelength range of blue LEDs like those in Hussell. (EX1020, 5:14-24; Fig. 2.)

177. Claim 20 (which depends from claim 19) recites substantially overlapping subject matter as claim 29, as shown in the table below:

<u>Element</u>	<u>Claim 20</u>	<u>Claim 29</u>
Light bulb	Claim 20	29[Pre]
Connector base	NA	29[a]
Solid state emitter and wavelength conversion component	19[a], 19[b]	29[b]
Wavelength conversion layer and light diffusing layer	19[b][1], 19[b][2]	29[c]
Light diffusing layer improves off-state white appearance	19[b][3]	29[d]
Blue light with $\geq 440\text{nm}$ wavelength emitted through the wavelength conversion component	19[b][4]	29[e]

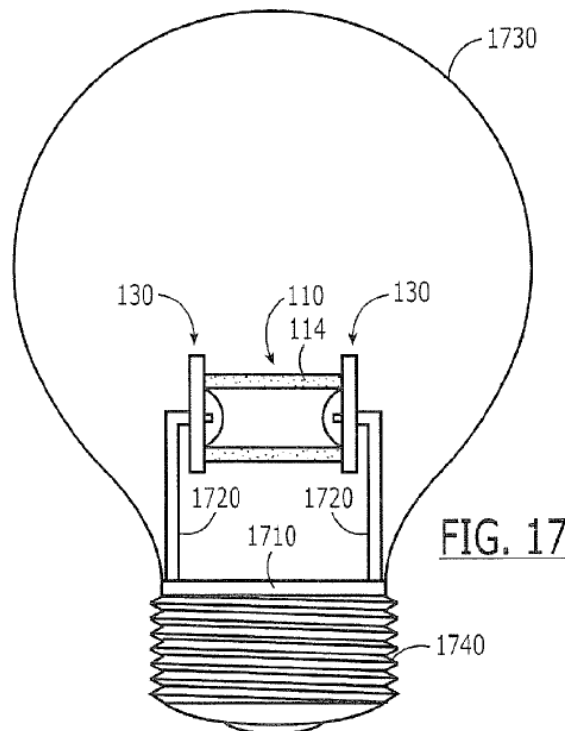
Claim 20: “The device of claim 19 wherein the light emitting device is selected from the group consisting of ... light bulbs”

Claim 29[Pre]: A light bulb comprising:

178. Hussell discloses a “semiconductor light emitting apparatus” (EX1011, Abstract) that can be implemented in various configurations including a light bulb. (See *id.* Fig. 17, ¶[0014], ¶[0052] (Figure 17 includes “bulb 1730”).)

Claim 29[a]: a connector base configured to be inserted in a socket to form an electrical connection for the light bulb

179. Hussell discloses this limitation. Figure 17 depicts an embodiment of the Hussell “semiconductor light emitting apparatus” in a light bulb having an Edison screw base which is a connector base configured to be inserted in a socket to form an electrical connection for the light bulb. Moreover, as shown below, Figure 17 includes “bulb 1730” and “screw-type base 1740” and Hussell notes that the wavelength conversion tube 110 and packaged light emitting devices 130 “provides a **filament** for drop-in replacement for an incandescent bulb.” (EX1011, ¶[0052] (emphasis added).) Such a bulb “may also employ voltage conversion circuits, thermal management systems, etc.” to facilitate electrical operation of the light bulb. *Id.*



Hussell, Figure 17

Claim 19[a]: at least one solid-state light emitter operable to generate excitation light

Claim 19[b]: a wavelength conversion component comprising

Claim 29[b]: a body comprising one or more solid-state light emitters; a wavelength conversion component having a three dimensional shape that is configured to enclose the one or more solid-state light emitters and to in part at least define a light mixing chamber

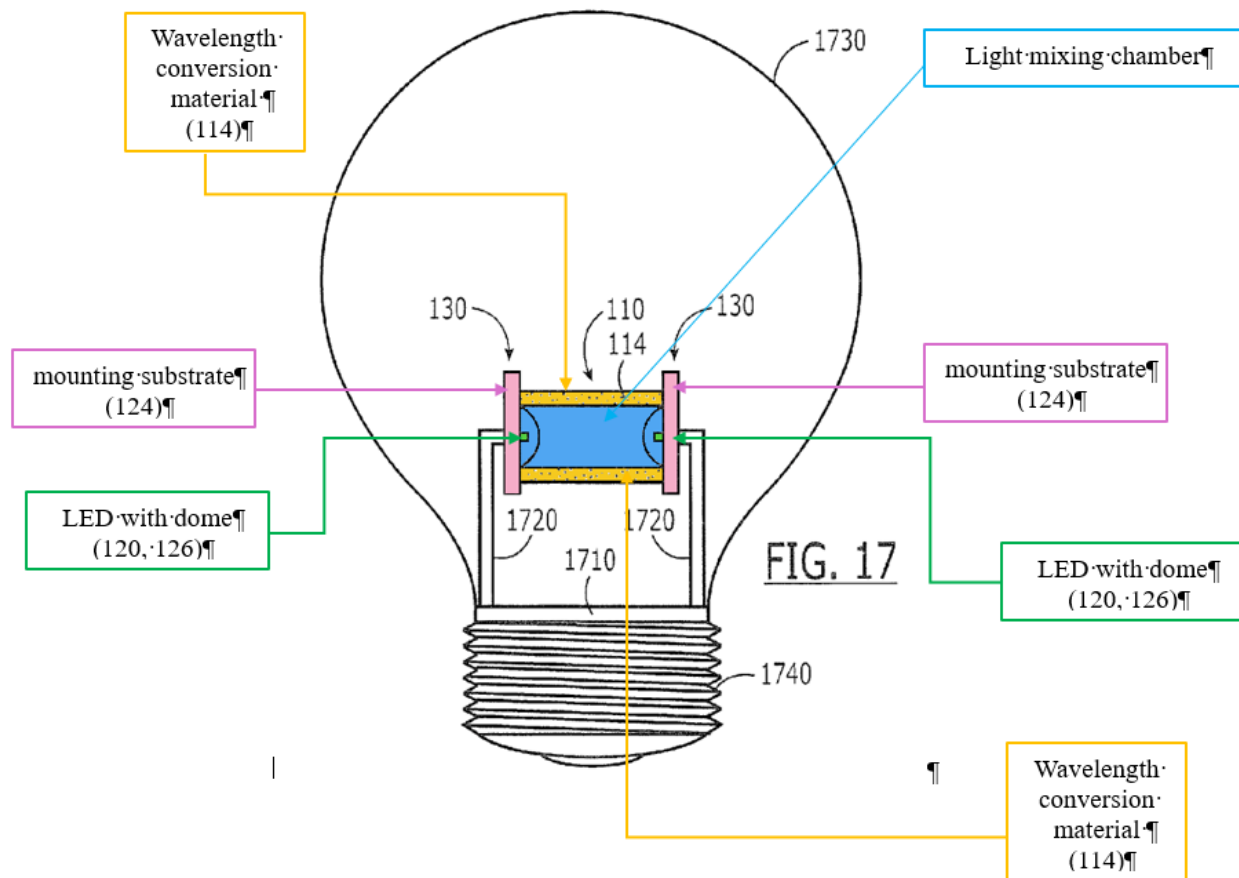
180. Hussell discloses these limitations. In the Figure 17 embodiment, Hussell teaches that the bulb “is connected to the screw-type base and surrounds the hollow wavelength conversion tube and the first and second semiconductor light emitting devices.” (EX1011, ¶[0014].) Hussell thus discloses a body (the bulb and the base) that is comprised of two solid-state light emitters (e.g., first and second semiconductor light emitting devices) which generate excitation light.

181. Moreover, as shown in the annotated Figure 17 below, the two LEDs in Hussell are contained within the ends of a three-dimensional wavelength conversion tube 110. (See also EX1011, ¶[0052] (“as shown in Fig. 17, an elongated hollow wavelength conversion tube 110 includes a packaged semiconductor device 130 at either end”).) (See also EX1011, ¶[0032], Fig. 1.)

182. The interior volume of hollow wavelength conversion tube 110 in the Figure 17 embodiment defines a light mixing chamber as shown in the image

below.³ (See also EX1011, ¶[0017] (“A respective light emitting filament comprises an elongated hollow wavelength conversion tube that includes an elongated wavelength conversion tube wall having wavelength conversion material dispersed therein, and a semiconductor light emitting device that is oriented to emit light inside the elongated hollow wavelength conversion tube.”); ¶[0041] (“the emitted light 122 from the semiconductor light emitting device 120 reflects off the inner surface of the tube wall 110, as shown by ray 310, and also refracts within the tube wall”).)

³ The '678 patent equates the light mixing chamber of the wavelength conversion component with its interior volume. (EX1001, 24:54-55 (“The interior volume may also be referred to as a light mixing chamber.”).)



Hussell, Annotated Figure 17

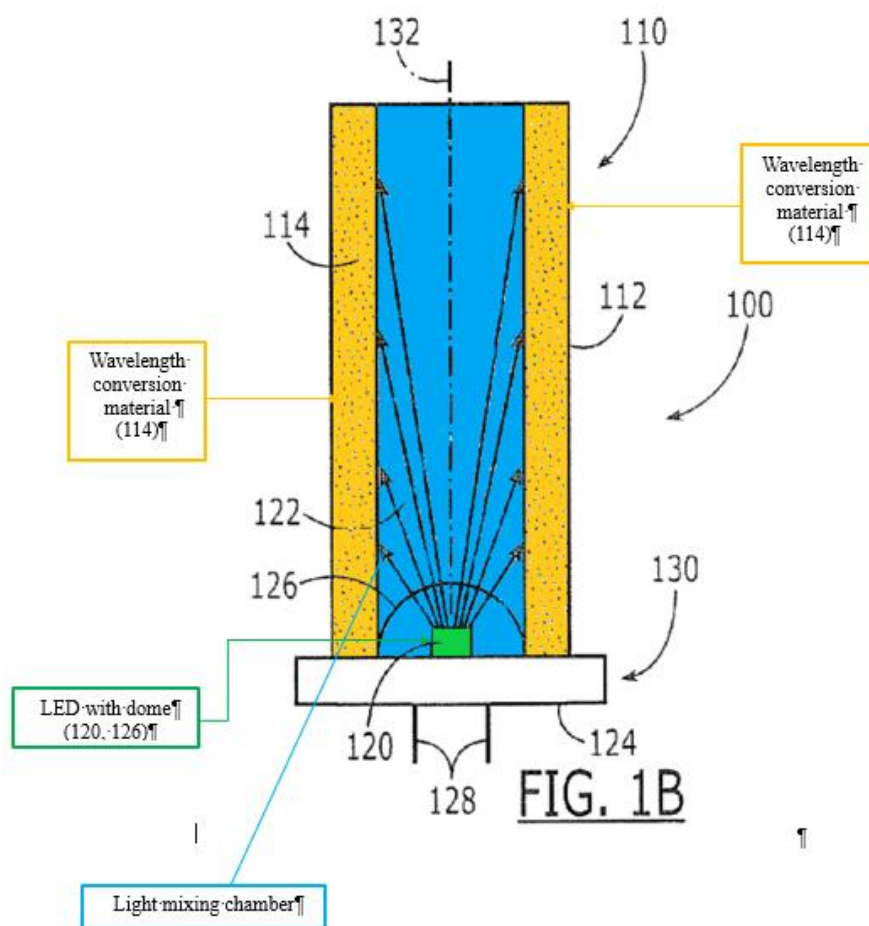
Claim 19[b][1]: A wavelength conversion layer excitable by the excitation light, wherein the wavelength conversion layer comprises particles of at least one photoluminescence material

Claim 19[b][2]: A light diffusing layer comprising particles of a light scattering material

Claim 29[c]: wherein the wavelength conversion component comprises a wavelength conversion layer comprising particles of at least one photoluminescence material and a light diffusing layer comprising particles of a light scattering material

183. The combination of Hussell and Basin-2007 discloses these limitations. As noted above, Hussell discloses a wavelength conversion tube. The

wavelength conversion tube includes a “tube wall having wavelength conversion material, such as phosphor, disposed therein.” (EX1011, Abstract.) Phosphor is a photoluminescence material because it converts light from one wavelength to another and is excitable by the blue, excitation light. “The tube wall may have a thickness of between about 0.05 mm and about 2 mm. Wavelength conversion particles 114 may be dispersed therein at concentrations between about 1% and about 70% by weight.” (*Id.*, ¶[0037].) “In order for the light 122, such as blue light, that emerges from the semiconductor light emitting device 120 to convert, for example to yellow light, it must impinge on a wavelength conversion material (e.g., phosphor) particle 114.” (*Id.*, ¶[0042].) The contents of the interior of the tube wall constitute the claimed wavelength conversion layer as shown in annotated Figure 1B below.



184. Hussell thus discloses a wavelength conversion component that includes a wavelength conversion layer comprising particles of at least one photoluminescence material.

185. It would have been obvious to a POSA to add a light diffusing layer on the outer surface of the tube wall in the wavelength conversion tube in Hussell in order to create an off-state white appearance in the “filament” disclosed in Hussell’s Figure 17 embodiment. Hussell discloses cerium-doped yttrium

aluminum garnet (YAG)⁴ as an exemplary “yellow phosphor” that can be used in the wavelength conversion tube. (EX1011, ¶[0006].) A POSA would understand that the YAG phosphor disclosed in Hussell (*see* EX1011, ¶[0036]) has the same unseemly yellow-ish appearance in the off state as the YAG phosphors in Basin-2007. As explained in Basin-2007, “[t]he YAG phosphor coating on the LED appears yellow-green under white ambient light when the LED is off. Such a yellow-green color is generally not attractive.” (EX1005, ¶[0004].)

186. A POSA’s motivation to modify the off-state appearance of the LED filament in Hussell is also evidenced by the teachings in Van Woudenberg (EX1020). Specifically, Van Woudenberg discloses the need to create an off-state white appearance in YAG phosphor-coated LEDs (pc-LEDs) used in general lighting devices such as luminaires and downlights. (*See* EX1020, Abstract.) As explained by Van Woudenberg:

pc-LEDs are applied in automotive headlights and in torches (for either terrestrial handheld, mountaineering headsets or diving purposes). Furthermore, as the efficacy and output power of pc-LEDs increases their

⁴ This is the same YAG phosphor used in Van Woudenberg and Basin for the same purpose – creating white light through phosphor conversion with a blue light LED. (EX1020, 5:19-20; EX1005, ¶¶[0027],[0028].)

penetration in general purpose illumination devices is expected to grow considerably.

In a large number of the above-mentioned applications of pc-LEDs the user can look directly into the LED package(s) assembled in the lighting device. . . .

Whenever the pc-LED package is visible to the user in the functional off state of the lighting device it can be clearly recognized by its distinguished yellowish color.

....

The distinguished yellowish appearance of pc-LEDs and the luminaires in their functional off state is in a large number of applications a disturbing feature.

(See EX1020, 1:14-28.)

187. Hussell, like Van Woudenberg, teaches a general illumination device, an LED light bulb. Accordingly, Van Woudenberg evidences why a POSA would be motivated to change the unattractive off-state yellow-ish appearance of Hussell's YAG phosphor wavelength conversion tube to a more neutral off-state white appearance.

188. Like Van Woudenberg, Basin-2007 teaches the need to avoid the off-state yellow-green appearance of YAG phosphors in pc-LED applications such as flash cameras for mobile phones, flashlights and projector lamps. (EX1005, [¶0009].) Thus, in view of Van Woudenberg, a POSA would be motivated to use

the solution provided by Basin-2007 in general lighting applications like light bulbs.

189. Moreover, a POSA would have had a reasonable expectation of success in adding a light diffusing layer comprising particles of a light scattering material to the outer surface of the wavelength conversion tube in Hussell in order to create a white appearance in the off-state. As discussed above, the light diffusing layer in Basin-2007 is comprised of light scattering particles (e.g., TiO_2) dispersed in silicone. (EX1005, ¶[0031].) Basin-2007 discloses that the light diffusing layer (also referred to as a silicone encapsulant) can be “spun on” or “molded directly over” an LED and phosphor. (EX1005, ¶[0031].) A POSA would understand that a layer that is “spun on” is simply a coating applied to another material. Moreover, because Hussell discloses that the wavelength conversion tube can be constructed from a wide variety of materials including plastic, epoxy or silicone, (EX1011, ¶[0034]) a POSA would have a reasonable expectation of success in applying light scattering particles (e.g., TiO_2) dispersed in silicone as taught in Basin-2007 to the outer surface of the wavelength conversion tube in a coating or other method taught by Hussell such as molding or extrusion. (EX1011, ¶[0036]).

190. Hussell also teaches that it is desirable to increase the light scattering properties of the wavelength conversion tube by texturing the exterior surface. (“[T]he elongated tube wall 112 includes inner and outer surfaces wherein the

inner and/or outer surfaces are textured as shown. The texturing may be uniform and/or non-uniform. Texturing may enhance scattering of light.” (EX1011, ¶[0048].) Adding a layer of light scattering particles to the exterior surface of the tube as taught by Basin-2007 would also enhance light scattering. (See, e.g., EX1005, ¶[0037].) This provides a separate motivation for a POSA to combine the TiO₂-containing layer of Basin-2007 with Hussell.

191. Thus, the wavelength conversion tube in Hussell as modified to include a light diffusing layer on the outer surface, constitutes the “wavelength conversion component” as claimed in this limitation.

Claim 19[b][3] and 29[d]: wherein the light diffusing layer improves an off-state white appearance of the wavelength conversion component;

192. The combination of Hussell and Basin-2007 discloses this limitation. As noted above, the light diffusing layer as taught by Basin-2007 improves an off-state white appearance of a wavelength conversion component. Accordingly, Hussell as modified to add the light diffusing layer as taught in Basin-2007 to the outer surface of the wavelength conversion tube, discloses a light diffusing layer that improves an off-state white appearance of the wavelength conversion component.

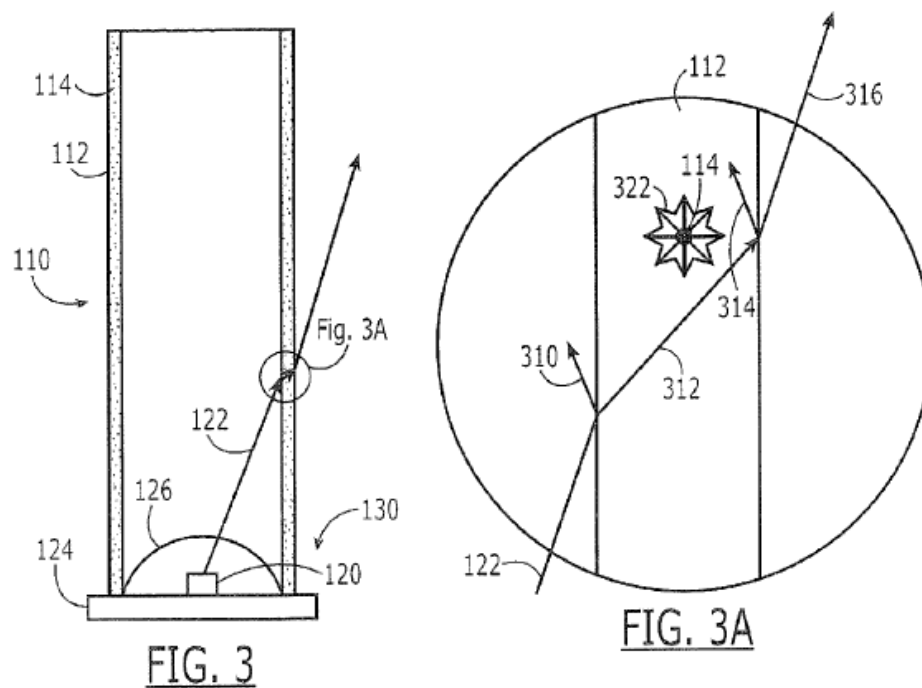
Claim 19[b][4] and 29[e]: wherein the wavelength conversion component is configured such that in operation a portion of light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the [at least one/ one or more] solid-state light emitter[s] is emitted through the wavelength conversion component to contribute to a final visible emission product.

193. The combination of Hussell, Van Woudenberg, and Basin-2007 discloses this limitation. Hussell discloses a tube wall having a thickness of between about 0.05 mm and about 2 mm with wavelength conversion particles dispersed therein at concentrations between about 1% and about 70% by weight. The use of an elongated hollow wavelength conversion tube according to various embodiments of the invention may provide efficient white light.” (EX1011, ¶[0037].) At least some blue light emitted from the semiconductor device would thus be emitted through the wavelength conversion component at a wavelength greater than or equal to 440 nm. Indeed, Hussell itself explains, through reference to Figures 3 and 3A, why this is the case:

[R]eferring to FIGS. 3 and 3A, the emitted light 122 from the semiconductor light emitting device 120 reflects off the inner surface of the tube wall 110, as shown by ray 310, and also refracts within the tube wall, as shown by ray 312. Additional internal reflection takes place from the outer wall, as shown as by ray 314, and **some of the original light 316 emerges from the tube.** The path through the wall 112 is indicated by ray 312. In contrast, when light strikes a phosphor particle 114 that is

embedded within the tube wall 112, it is converted and scattered in all directions, as shown by the rays 322.

(EX1011, ¶[0041] (emphasis added).) (See also *id.*, ¶[0042] and ¶[0006] (“[A] blue emitting LED may be surrounded by a yellow phosphor... The resulting light, which is a combination of blue light and yellow light, may appear white to an observer.”).)



194. A POSA would likewise understand that the blue light emitted by the semiconductor light emitting device in Hussell in view of Van Woudenberg, further in view of Basin-2007 has a wavelength of greater than or equal to 440 nm. As explained in Van Woudenberg, the “primary light” emitted by an LED chip typically has a wavelength between 430 and 480 nm with the greatest distribution at around 440 nm. (EX1020, 5:14-24.) As shown in Figure 2 of Van Woudenberg

(reproduced below), light that hits the phosphor is converted to a much longer wavelength.

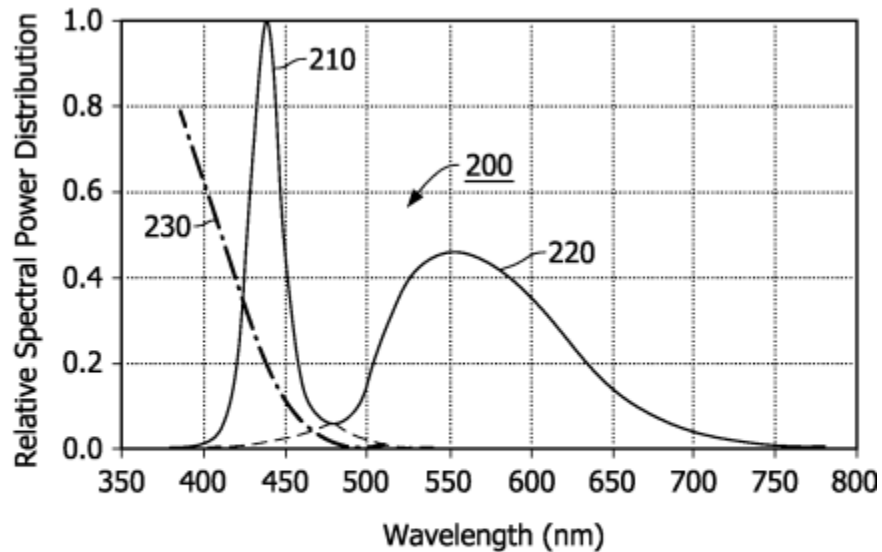


FIG. 2

195. Hussell has same purpose as Van Woudenberg – the creation of white light through YAG phosphor conversion using blue light LEDs – thus a POSA would have been motivated to use LEDs emitting blue light having wavelengths between 430-480nm according to Van Woudenberg in Hussell. Modifying Hussell to add a light diffusing layer would not have any effect on the wavelength of the blue light emitted through wavelength conversion component.

196. Hussell in view of Van Woudenberg, further in view of Basin-2007 thus discloses this limitation.

[GROUND 3] Claims 1, 2, 3, 6, 10, 16, 19, 21, and 25 are rendered obvious by Krummacher and Stokes (incorporating Shimizu)

197. Krummacher discloses a white light LED light source with a blue light LED chip, a phosphor-containing wavelength conversion layer, and a TiO₂-particle-containing light diffusion layer, thus rendering obvious claims 1, 2, 3, 6, 10, 16, 19, 21, and 25 of the '678 patent.

FIG 1

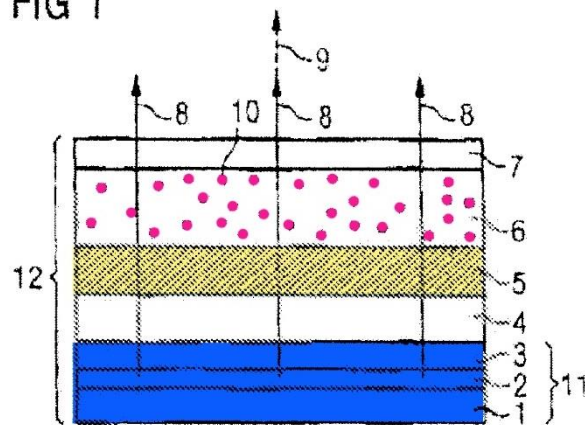
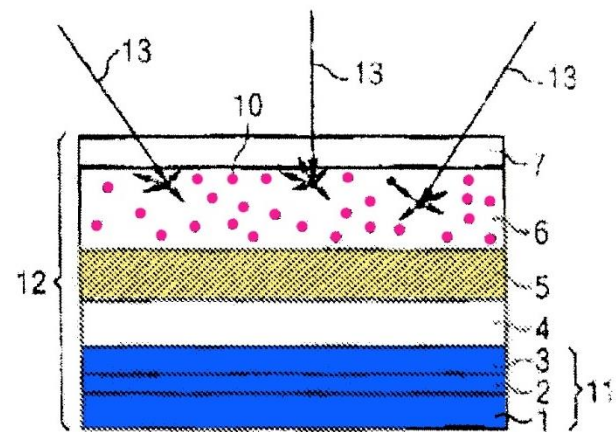


FIG 2



Independent Claim 1: Wavelength Conversion Component

198. Claim 1 of the '678 patent reads as follows:

[1pre] A wavelength conversion component for a light emitting device comprising:

- [1a] a wavelength conversion layer comprising particles of at least one photoluminescence material; and
- [1b] a light diffusing layer comprising particles of a light scattering material,

- [1c] wherein the light diffusing layer improves an off-state white appearance of the wavelength conversion component;
- [1d] wherein the wavelength conversion component is configured such that in operation a portion of excitation light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the light emitting device is emitted through the wavelength conversion component to contribute to a final visible emission product.

199. Krummacher discloses each of these claim requirements as detailed below.

[1pre] A wavelength conversion component for a light emitting device

200. Krummacher discloses a wavelength conversion component.

Krummacher discloses:

An optoelectronic component having an active layer that emits electromagnetic radiation when the component is on and a luminescence conversion layer disposed after said active layer in a radiation direction of said electromagnetic radiation, the luminescence conversion layer is followed in the radiation direction by a light-scattering translucent layer. The luminescence conversion layer preferably appears white owing to the light-scattering translucent layer disposed after it.

(EX1007, [57].)

201. Accordingly, it is my opinion that Krummacher discloses a light emitting device with a wavelength conversion component.

[1a] a wavelength conversion layer comprising particles of at least one photoluminescence material

202. Krummacher discloses the inclusion of a wavelength conversion layer comprising particles of at least one photoluminescence material. It is shown, for example, as layer 5 in the annotated Figures 1 and 2 above.

203. Krummacher discloses that “[t]he luminescence conversion material of the luminescence conversion layer 5 is advantageously embedded in a transparent matrix, for example in polycarbonate, silicone, epoxy or PMMA.”

(EX1007, [0037]; *see also id.*, [0023].) Krummacher describes the purpose of the layer as follows:

At least a portion of the radiation emitted by the active layer 2 is converted by the luminescence conversion layer 5 to a longer wavelength. In particular, ultraviolet or blue radiation emitted by active layer 2 can be converted to radiation having a longer wavelength, particularly of a complementary color, such as yellow, for example, to produce white light. Luminescence conversion materials suitable for this purpose are known, for example, from the document WO97/50132, whose disclosure content in this regard is hereby incorporated by reference. Particularly suitable are cerium-doped garnets, such as YAG:Ce, for

example.

(EX1007, [0036].)

204. Accordingly, it is my opinion that Krummacher discloses a wavelength conversion layer comprising particles of at least one photoluminescence material.

[1b] a light diffusing layer comprising particles of a light scattering material

205. Krummacher discloses the inclusion of a light diffusing layer comprising particles of a light scattering material. It is shown, for example, as layer 6 in the annotated Figures 1 and 2 above.

206. In particular, Krummacher discloses that:

The luminescence conversion layer 5 is followed in the radiation direction 9 by a light-scattering translucent layer 6. Said light-scattering translucent layer 6 is advantageously at least partially transparent to the radiation 8 emitted by active layer 2 and at least partially converted by luminescence conversion layer 5.

(EX1007 at [0038].) Krummacher further discloses the light diffusing layer containing TiO₂ particles:

In this exemplary embodiment, the light-scattering translucent layer 6 contains light-scattering particles 10, which, as illustrated in FIG. 2, serve to scatter environmental light 13 striking the optoelectronic component from the outside. Such scattering particles are

known, for example, in the production of frosted glass. Particularly suitable are particles of TiO_2 or Al_2O_3 , preferably having a radius of between 50 nm inclusive and 1000 nm inclusive. Alternatively, spherical or hollow-sphere-shaped particles of glass or synthetic material are also suitable.

(EX1007 at [0039].)

207. Accordingly, it is my opinion that Krummacher discloses a light diffusing layer comprising particles of a light scattering material.

[1c] wherein the light diffusing layer improves an off-state white appearance of the wavelength conversion component

208. Krummacher discloses that the light diffusing layer improves an off-state white appearance of the wavelength conversion component.

209. In particular, Krummacher discloses:

In this method of generating white light by luminescence conversion, the optical impression produced by the optoelectronic component when it is in the off state frequently is not satisfactory. The reason for this is that in a bright environment, the luminescence conversion layer is stimulated to emit yellow light even when the optoelectronic component is off, but without the superimposition of blue light to yield white light, as when it is on. As a result, in the off state, the surface of the optoelectronic component in the areas provided with the luminescence conversion layer exhibit the color of the

longer wavelength produced by luminescence conversion—yellow, for example—which is often found unattractive by observers.

(EX1007 at [0004].) Thus, Krummacher discloses:

[0040] Light scattering notwithstanding, the light-scattering translucent layer 6 is at least partially transparent to the radiation 8 emitted by the active layer 2. At the same time, due to the scattering of light in light-scattering translucent layer 6, the elements located thereunder, particularly the luminescence conversion layer 5, can be perceived only hazily or not at all by an observer looking at the optoelectronic component from a direction opposite to the radiation direction 9.

[0041] Advantageously, the distribution, size and material of the light-scattering particles 10 in light-scattering translucent layer 6 are selected such that the surface of light scattering translucent layer 6 appears white. In this way, the luminescence conversion layer 5 is advantageously prevented from exhibiting a yellowish hue, in the off state of the optoelectronic component depicted in FIG. 2, due to stimulation of the luminescence conversion materials by environmental light 13 incident from the outside.

(EX1007.)

210. Accordingly, it is my opinion that Krummacher discloses the light diffusing layer improves an off-state white appearance of the wavelength conversion component.

[1d] wherein the wavelength conversion component is configured such that in operation a portion of excitation light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the light emitting device is emitted through the wavelength conversion component to contribute to a final visible emission product

211. Krummacher discloses that a portion of excitation light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the light emitting device is emitted through the wavelength conversion component to contribute to the final visible emission product.

212. That is, for example, Krummacher discloses that:

Known from the document WO 97/50132 is a radiation-emitting optoelectronic component in which at least a portion of the radiation emitted by an active layer of said optoelectronic component is converted to larger wavelengths by means of a luminescence conversion layer. In this way, for example a radiation-emitting active region that emits blue or ultraviolet light can be used to generate mixed-color or white light. As a rule, blue or ultraviolet light is converted by such a luminescence conversion layer to light of a longer wavelength, particularly to light of a complementary color, such as yellow, for example, such that the blue or ultraviolet

radiation emitted by the active region is superimposed on the fraction converted to the complementary color to yield white light.

(EX1007 at [0003].)

213. Although Krummacher does not specify the wavelength of blue light emitted by its LED chip, a POSA would have understood it to include blue light with a wavelength greater than 440 nm. In addition to being a white light emitting LED device, Krummacher discloses that “the optoelectronic component is for example an LED or an LED light source comprising one or more radiation-emitting semiconductor chips, in which case said semiconductor chip or chips emit blue or ultraviolet light that is converted to white light by the luminescence conversion layer. (EX1007 at [0022].) Krummacher discloses that “active layer 2 is preferably an organic light-emitting layer, particularly emitting blue light” or “an inorganic semiconductor material, preferably emitting in the blue and/or ultraviolet region of the spectrum.” (EX1007 at [0031]-[0032].) “The active layer 2 can in particular comprise a nitride compound semiconductor material, for example $\text{In}_x\text{Al}_y\text{Ga}_{1-x-y}$ where $0 \leq x \leq 1$ and $x+y \leq 1$.” (EX1007 at [0032].)

214. Moreover, a white light LED light source containing a blue light LED chip generating “blue light having a wavelength of greater than or equal to 440 nm” would have been obvious in view of Stokes, which incorporates Shimizu. Stokes and Shimizu both disclose white light LED light sources consistent with

claims 1 and 19 of the '678 patent. As discussed above with respect to the state of the art, Shimizu provides wavelength charts for multiple blue light LED chips, all of which show emission light including wavelengths above 440 nm. (EX1010, Figs.) Shimizu further discloses a dozen examples with blue light LED chips having emission peaks at 450 nm (23:43, 27:4-5, 28:55), 460 nm (25:24-25), or 470 nm (29:45), but none at shorter wavelengths. And Stokes discloses an LED chip that “emits blue light 48 having a wavelength between about 420 and 480 nm” (EX1008 at 4:37-40) along with “blue emitting LEDs having a peak emission wavelength of $\lambda=450$ nm” or “peak emission wavelength of $\lambda=480$ nm” (EX1008 at 6:62-67).

215. A POSA would have been motivated to use a white light LED light source disclosed by Stokes and Shimizu as the conventional white light LED called for by Krummacher. Shimizu, in particular, is cited by both the '678 patent and the prior art. Thus, it would have been obvious to look to Shimizu and Stokes for details of the conventional white light LED light source used in Krummacher. And a POSA would have had a reasonable expectation of success in doing so, because they would simply be using the conventional white light LED disclosed in the prior art as directed by Krummacher. In other words, not only does Krummacher suggest the use of an LED like that disclosed in Stokes and Shimizu, to do so would have

been the simple substitution of one known element for another to obtain predictable results.

216. Accordingly, it is my opinion that Krummacher discloses or suggests the wavelength conversion component is configured such that in operation a portion of excitation light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the light emitting device is emitted through the wavelength conversion component to contribute to a final visible emission product.

217. It is my opinion that Krummacher thus teaches all of the elements of claim 1 and renders claim 1 obvious as a whole.

Claim 2: Layers in Direct Contact

218. Claim 2 requires “[t]he component of claim 1, wherein the wavelength conversion layer and the light diffusing layer are in direct contact with each other.”

219. As discussed above, Krummacher discloses or renders obvious claim 1.

220. Krummacher further discloses that the wavelength conversion layer and the light diffusing layer are in direct contact with each other. As shown in Figures 1 and 2 (annotated here), “[t]he luminescence conversion layer 5 is

followed in the radiation direction 9 by a light-scattering translucent layer 6” and the layers are in direct contact. (EX1007 at [0038].) Indeed, “[i]n a particularly preferred embodiment, the light scattering translucent layer is applied directly to the luminescence conversion layer.” (EX1007 at [0018].)

FIG 1

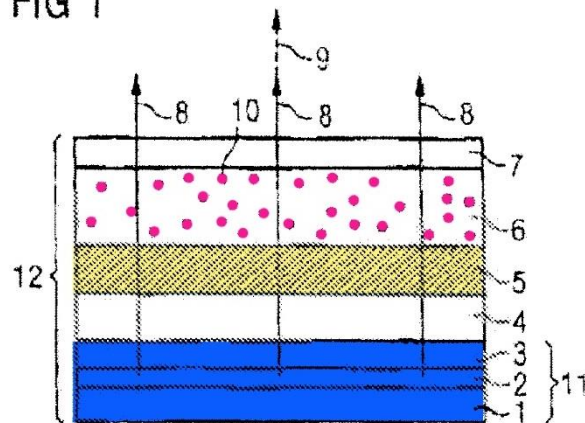
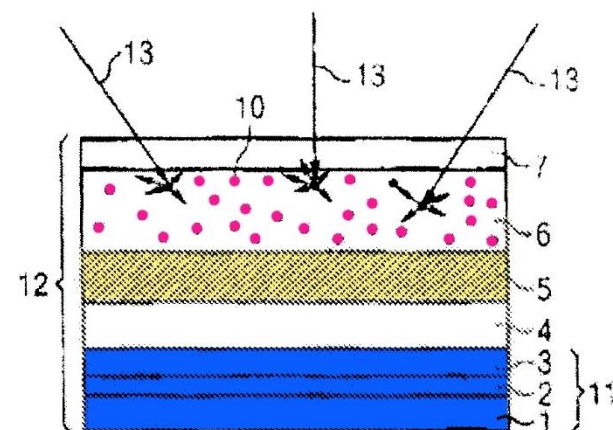


FIG 2



221. It is my opinion that Krummacher thus teaches all of the elements of claim 2 and renders claim 2 obvious as a whole.

Claim 3: Layers in Light Transmissive Binder

222. Claim 3 requires “[t]he component of claim 1, wherein the wavelength conversion layer comprises a mixture of the at least one phosphor material and a light transmissive binder and the light diffusing layer comprises a mixture of the light scattering material and the light transmissive binder.”

223. As discussed above, Krummacher discloses or renders obvious claim 1. Krummacher further discloses the wavelength conversion layer and the light

diffusing layer both being mixtures including a light transmissive binder, such as silicone.

224. As discussed above, Krummacher discloses that “[t]he luminescence conversion material of the luminescence conversion layer 5 is advantageously embedded in a transparent matrix, for example in polycarbonate, silicone, epoxy or PMMA.” (EX1007 at [0037].) Krummacher further discloses:

In a further preferred embodiment, the light-scattering translucent layer is a layer of synthetic material. The layer of synthetic material can in particular be applied by laminating or gluing. Alternatively, the layer of synthetic material can also be produced by spin coating, for example. In this fashion, even relatively large radiation-emitting areas, particularly large-area lighting units, can be provided with the light-scattering translucent layer with relatively little production expenditure.

(EX1007 at [0014].)

225. Silicone is an example of an appropriate synthetic material and is disclosed by Krummacher. Accordingly, Krummacher discloses that both the light diffusing layer and the wavelength converting layer may be made of a mixture with a light transmissive binder such as silicone.

226. Although Krummacher does not expressly specify that both layers use the same light transmissive binder, a POSA would have understood Krummacher

to disclose both layers being a silicone binder. A POSA would understand that using a single transmissive binder would result in the layers having similar refractive indexes and thus minimize reflection loss. (See EX1007 at [0002] (“Further, it is advantageous if the refractive index of the adhesive is matched to the refractive index of the light-scattering translucent layer and/or of the luminescence conversion layer to minimize reflection losses at the interface.”). (See EX1007 at [0012])). While it is possible to find binder materials with the same refractive indexes, the most obvious way to do so is to use the same materials. Using a silicone binder is also consistent with avoiding absorption losses. (See EX1007 at [0016] (“The thickness of the light-scattering translucent layer is advantageously selected so that it has a sufficient light-scattering effect but absorption losses in the layer are quite low. The layer thickness of the translucent layer is preferably 500 μm or less.”).)

227. Moreover, Shimizu discloses that the light diffusing layer is made of silicone: “the molding material 104, transparent materials having high weatherability such as epoxy resin, urea resin, silicon[e] resin or glass is preferably employed.” (EX1010 at 17:6-9). Shimizu further discloses that the wavelength conversion layer is made of silicone: “The coating material [101] may be a transparent material having good weatherability such as epoxy resin, urea resin and silicon[e] or glass.” (EX1010 at 16:47-49.)

228. Stokes also discloses that the light diffusing layer is made of silicone: “the radiation scattering particles comprise ceramic or other insulating particles dispersed in the carrier medium selected from glass, such as SiO₂, or a plastic material or a polymer, such as epoxy, silicone or urea resin.” (EX1008 at 6:36-40.) Stokes further discloses that the wavelength conversion layer is made of silicone: “the luminescent material 45 comprises a packed phosphor particle layer or a dispersion of phosphor particles in a polymer encapsulating material[, which] may comprise epoxy or silicone.” (EX1008 at 6:6-9.)

229. A POSA would have been motivated to use the binder disclosed by Stokes and Shimizu with the conventional white light LED called for by Krummacher. Shimizu, in particular, is cited by both the '678 patent and the prior art. Thus, it would have been obvious to look to Shimizu and Stokes for details of the conventional white light LED light source used in Krummacher. And a POSA would have had a reasonable expectation of success in doing so, because they would simply be using the conventional white light LED disclosed in the prior art as directed by Krummacher. In other words, not only does Krummacher suggest the use of an LED with a binder like that disclosed in Stokes and Shimizu, to do so would have been the simple substitution of one known element for another to obtain predictable results.

230. It is my opinion that Krummacher thus discloses or suggests all of the elements of claim 3 and renders claim 3 obvious as a whole.

Claim 6: Light Transmissive Binder is Silicone

231. Claim 6 requires “[t]he component of claim 3, wherein the light transmissive binder comprises a curable liquid polymer selected from the group consisting of: a polymer resin, a monomer resin, an acrylic, an epoxy, a silicone and a fluorinated polymer.”

232. As discussed above, Krummacher discloses or renders obvious claim 3. As also discussed above with respect to claim 3, Krummacher particularly discloses silicone as a light-transmissive binder. That is, Krummacher discloses that “[t]he luminescence conversion material of the luminescence conversion layer 5 is advantageously embedded in a transparent matrix, for example in polycarbonate, silicone, epoxy or PMMA.” (EX1007 at [0037].)

233. Moreover, Shimizu discloses that the light diffusing layer is made of silicone: “the molding material 104, transparent materials having high weatherability such as epoxy resin, urea resin, silicon[e] resin or glass is preferably employed.” (EX1010 at 17:6-9). Shimizu further discloses that the wavelength conversion layer is made of silicone: “The coating material [101] may be a transparent material having good weatherability such as epoxy resin, urea resin and silicon[e] or glass.” (EX1010 at 16:47-49.)

234. Stokes also discloses that the light diffusing layer is made of silicone: “the radiation scattering particles comprise ceramic or other insulating particles dispersed in the carrier medium selected from glass, such as SiO₂, or a plastic material or a polymer, such as epoxy, silicone or urea resin.” (EX1008 at 6:36-40.) Stokes further discloses that the wavelength conversion layer is made of silicone: “the luminescent material 45 comprises a packed phosphor particle layer or a dispersion of phosphor particles in a polymer encapsulating material[, which] may comprise epoxy or silicone.” (EX1008 at 6:6-9.)

235. A POSA would have been motivated to use the binder disclosed by Stokes and Shimizu with the conventional white light LED called for by Krummacher. Shimizu, in particular, is cited by both the '678 patent and the prior art. Thus, it would have been obvious to look to Shimizu and Stokes for details of the conventional white light LED light source used in Krummacher. And a POSA would have had a reasonable expectation of success in doing so, because they would simply be using the conventional white light LED disclosed in the prior art as directed by Krummacher. In other words, not only does Krummacher suggest the use of an LED with a binder like that disclosed in Stokes and Shimizu, to do so would have been the simple substitution of one known element for another to obtain predictable results.

236. It is my opinion that Krummacher thus teaches all of the elements of claim 6 and renders claim 6 obvious as a whole.

Claim 10: Light Scattering Material is TiO₂

237. Claim 10 requires “[t]he component of claim 1, wherein the light scattering material is selected from the group consisting of: titanium dioxide, barium sulfate, magnesium oxide, silicon dioxide and aluminum oxide.”

238. As discussed above, Krummacher discloses or renders obvious claim 1. As also discussed above with respect to the light diffusing layer requirement of claim 1, Krummacher discloses TiO₂ as a light scattering material. (EX1007 at [0039] (“Particularly suitable are particles of TiO₂ or Al₂O₃, preferably having a radius of between 50 nm inclusive and 1000 nm inclusive.”).)

239. It is my opinion that Krummacher thus teaches all of the elements of claim 10 and renders claim 10 obvious as a whole.

Claim 16: Planar Shapes

240. Claim 16 requires “[t]he component of claim 1 in which the wavelength conversion layer and the light diffusing layer comprises planar shapes.”

241. As discussed above, Krummacher discloses or renders obvious claim 1. As in Figures 1 and 2 above, Krummacher discloses a wavelength conversion

layer and light diffusing layers that comprise planar (i.e., flat) shapes, because they are flat layers. Indeed, Krummacher teaches:

The thickness of the light-scattering translucent layer is advantageously selected so that it has a sufficient light-scattering effect but absorption losses in the layer are quite low. The layer thickness of the translucent layer is preferably 500 μm or less.

(EX1007 at [0016].)

242. It is my opinion that Krummacher thus teaches all of the elements of claim 16 and renders claim 16 obvious as a whole.

Independent Claim 19: Light Emitting Device

243. Claim 19 of the '678 patent reads as follows:

19. A light emitting device comprising:
at least one solid-state light emitter operable to generate
excitation light; and
a wavelength conversion component comprising:
a wavelength conversion layer excitable by the excitation
light, wherein the wavelength conversion layer comprises
particles of at least one photoluminescence material; and
a light diffusing layer comprising particles of a light
scattering material,
wherein the light diffusing layer improves an OFF state
white appearance of the wavelength conversion
component;

wherein the wavelength conversion component is configured such that in operation a portion of light comprising blue light having a wavelength of greater than or equal to 440 nm generated by the at least one solid-state light emitter is emitted through the wavelength conversion component to contribute to a final visible emission product.

244. Krummacher discloses a “light emitting device” in the form of an LED or LED light source comprising a blue-light-emitting semiconductor chip coupled with a luminescent conversion layer to produce white light. EX1007 at [0022]. Claim 19 is essentially identical to claim 1 except that claim 19 also encompasses the “solid-state light emitter operable to generate excitation light,” or LED chip. As discussed in detail above with respect to claim 1, Krummacher discloses each of these claim requirements as arranged in the claim, including the LED chip. (*See also* EX1007 at [0004] (explaining relevance to lighting based on “organic light-emitting diodes (OLEDs)” and “LEDs or LED light sources having one or more radiation-emitting semiconductor chips”).

245. It is my opinion that Krummacher thus teaches all of the elements of claim 19 and renders claim 19 obvious as a whole.

Claim 21: Improved Off-State White Appearance

246. Claim 21 requires “[t]he device of claim 19 in which the light scattering material within the light diffusing layer corresponds to an average

particle size that improves the OFF state white appearance of the wavelength conversion component.”

247. As discussed above, Krummacher discloses or renders obvious claim 19. And as discussed in detail with respect to requirement [1c] of claim 1, Krummacher further discloses that the light diffusing layer improves an off-state white appearance. Given that Krummacher discloses the light diffusing layer improves an off-state white appearance, the light diffusing layer has “an average particle size that improves the OFF state white appearance” as required by claim 21. In any case, Krummacher also discloses that the light-scattering particles “[p]articularly suitable are particles of TiO_2 or Al_2O_3 , preferably having a radius of between 50 nm inclusive and 1000 nm inclusive. (EX1007 at [0010].)

248. Moreover, an “average particle size that improves OFF state white appearance” would have been obvious in view of Stokes and Shimizu. Shimizu teaches this requirement. It discloses “[a]s a dispersant, barium titanate, titanium oxide [i.e., titanium(IV) oxide, or TiO_2], aluminum oxide, silicon dioxide and the like can be used.” (EX1010 at 17:9-11.) It further discloses:

According to the present invention, adding the dispersant and/or a coloration agent in the molding material has the effects of masking the color of the fluorescent material obscured and improving the color mixing performance. That is, the fluorescent material absorbs blue component

of extraneous light and emits light thereby to give such an appearance as though colored in yellow. However, the dispersant contained in the molding material gives milky white color to the molding material and the coloration agent renders a desired color. Thus the color of the fluorescent material will not be recognized by the observer.

(EX1010 at 17:25-35.) Given that, as discussed in detail above, Shimizu discloses a white light LED light source consistent with the claims and covered by a light diffusing layer of silicone containing TiO_2 particles, Shimizu alone anticipates every requirement of claim 1.

249. Stokes also discloses a light diffusing layer that contains TiO_2 particles. Stokes discloses considerations for choosing an average particle size in the context of a light diffusing layer. (*E.g.*, EX1008 at 7:1:26.) Of particular note, Stokes discloses that:

In one preferred embodiment, the radiation scattering particles have a size such that the particles preferentially scatter blue or UV LED light as compared to yellow, green, red or white light from the luminescent material. Preferably, the particle size is selected such that the particles scatter at least 50% more radiation source radiation than luminescent material radiation. FIG. 6 illustrates the relationship between the particle diameter and the wavelength of the scattered light for Ti-Pure®

rutile TiO_2 particles made by DuPont. As illustrated in FIG. 6, the relative scattering power of 100 to 200 nm TiO_2 particles is above 1 for blue incident radiation, while it is below 1 for green and red incident radiation. Therefore, as illustrated in FIG. 6, 100 to 200 nm particles have at least a 50% greater scattering power for blue radiation (i.e., such as that emitted by a blue emitting LED) than green or red (or for that matter yellow) radiation (i.e., such as that emitted by the phosphor or dye). This particle size range is advantageous because it enhances the scattering of the radiation source radiation while it decreases the amount of scattering of the luminescent material radiation. Therefore, the lamp radiation output is rendered more uniform because a greater amount of radiation source radiation is scattered toward the luminescent material, while a lesser amount of the luminescent material radiation that is emitted downward toward the radiation source is scattered back toward the luminescent material.

(EX1008 at 7:1-26.) As shown below, Figure 6 of Stokes is essentially identical to Figure 10 of the '678 patent. It appears that the applicants copied Figure 10 from a 2007 DuPont brochure (EX1012, fig.4; EX1013, fig.7) without attribution.

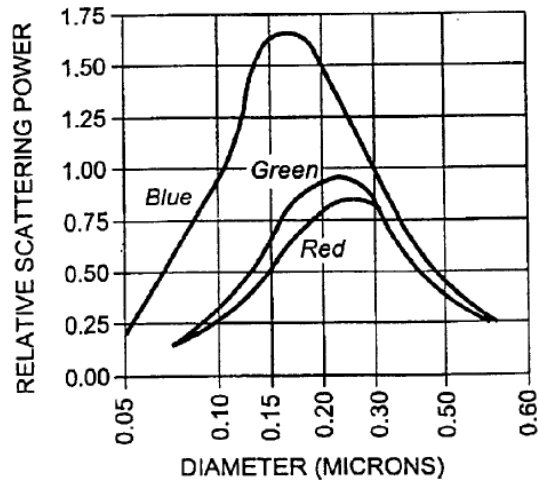


fig. 6
(PRIOR ART)

2:

(EX1008).

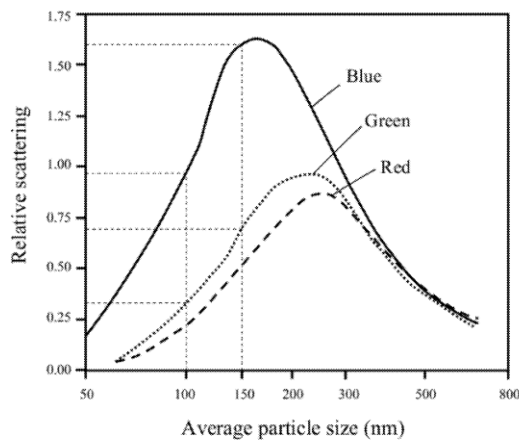


FIG. 10

(EX1001).

250. As discussed above, a POSA would have looked to the state of the art such as Stokes for the details of a conventional white light LED, particularly because it is directed to a light diffusing layer. Thus, it would have been obvious to look to Stokes, which incorporates Shimizu, for details of the conventional white

light LED light source used in Krummacher. A POSA would have had a reasonable expectation of success given that the disclosures would be used for their expected functions.

251. It is my opinion that Krummacher thus discloses or suggests all of the elements of claim 25 and renders claim 21 obvious as a whole.

Claim 25: Planar Shapes

252. Claim 25 requires “[t]he device of claim 19 in which the wavelength conversion layer and the light diffusing layer comprises planar shapes.”

253. As discussed above, Krummacher discloses or renders obvious claim 19. And as discussed in detail with respect to claim 16, Krummacher further discloses that the wavelength conversion layer and the light diffusing layer comprises planar shapes.

254. It is my opinion that Krummacher thus teaches all of the elements of claim 25 and renders claim 25 obvious as a whole.

[GROUND 4] Claims 19, 20, and 29 are rendered obvious by Hussell, Krummacher, and Van Woudenberg

255. As discussed above, the prior art discloses conventional white-light LED light sources with light diffusing layers as required by the claims. Claims 20 and 29 further require that the white light LED light source be incorporated into a device such as a light bulb. (See Ground 2 listing above.)

256. As noted above, Hussell, in combination with Van Woudenberg discloses every element in claims 19, 20 and 29 except a light diffusing layer that improves an off-state white appearance of the wavelength conversion component. The teachings in those references also demonstrate why a person skilled in the art would be motivated to modify the “wavelength conversion tube” in Hussell to create an off-state white appearance.

257. Like Basin-2007, a POSA would also find a specific way to achieve the desired off-state white appearance through the teachings in Krummacher. This is at least because both Basin-2007 and Krummacher employ Ce:YAG particles in the wavelength conversion layer. (*Compare* EX1005, ¶[0028] *with* EX1007, [0036].) Krummacher discloses a variety of ways to add a light-scattering diffusion layer to a wavelength conversion component in order to achieve the desired off-state white appearance.

258. A POSA would have a reasonable expectation of success in applying the “light-scattering translucent layer” in Krummacher to the “wavelength conversion tube” Hussell. Krummacher discloses a variety of ways to combine its “light-scattering translucent layer” to a wavelength conversion layer. For example, Krummacher teaches that the “light-scattering translucent layer” can be a film which is then “laminated or glued onto luminescence conversion layer 5.” (EX1007, ¶[0042].) Alternative, this layer can be a “glass layer” that is “glued onto

the luminescence conversion layer.” (EX1007, ¶[0043].) A POSA would understand that such materials can be applied to the “wavelength conversion tube” in Hussell (which itself can be made from “plastic, epoxy, silicone and/or other transparent or translucent material” (EX1011, ¶[0036]) without undue experimentation. Indeed, Krummacher discloses techniques to facilitate adding the “light-scattering translucent layer” to the wavelength conversion layer, such as ways to “prevent reflection losses.” [See, e.g., EX1007, ¶[0043-44].)

259. Thus, it would have been obvious to modify Hussell in view of Van Woudenberg to add a “light-scattering translucent layer” to Hussell’s wavelength conversion tube and Krummacher renders claims 20 and 29 obvious as a whole.

XIII. SECONDARY CONSIDERATIONS

260. There is no evidence of nonobviousness which I am aware that affects—let alone overcomes—the strong cases of obviousness set out above.

XIV. CONCLUSION

261. 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 the time allotted for cross-examination.

262. I hereby 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.

Date: August 26, 2024

A handwritten signature in black ink, appearing to read "W. A. Doolittle", written over a horizontal line.

William A. Doolittle, Ph.D.