Filed on behalf of: Savant Techs. LLC d/b/a GE Lighting, Elong Int'l USA Inc.,
and Xiamen Longstar Lighting Co. Ltd.
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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. IPR2025-00698

Patent No. 8,614,539

PETITION FOR INTER PARTES REVIEW OF U.S. PATENT NO. 8,614,539

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LISTING OF CHALLENGED CLAIMS

1. A wavelength conversion component for a light emitting device comprising:

> at least one photoluminescence material; and
>
> a light scattering material, wherein the light scattering material has an average particle size that is selected such that the light scattering material will scatter excitation light from a radiation source relatively more than the light scattering material will scatter light generated by the at least one photoluminescence material;
>
> wherein the wavelength conversion component is configured such that in operation a portion of the excitation light comprising blue light having a wavelength of greater than or equal to 440 nm is emitted through the wavelength conversion component to contribute to a final visible emission product;
>
> wherein the light scattering material scatters the blue light at least twice as much as light generated by the at least one photoluminescence material.

2. The component of claim 1, wherein the light scattering material has an average particle size that is less than about 150 nm.

3. The 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.

4. The component of claim 1 wherein the at least one photoluminescence material is located in a wavelength conversion layer and the light scattering material is located in a diffusing layer.

5. The component of claim 4, wherein the wavelength conversion layer and the light diffusing layer are in direct contact with each other.

6. The component of claim 4, 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.

7. The component of claim 6, 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.

8. The component of claim 6, wherein the weight loading of light scattering material to binder selected from the group consisting of: 7% to 35% and 10% to 20%.

9. The component of claim 4, 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.

10. The component of claim 4 in which the wavelength conversion layer and the light diffusing layer comprises planar shapes.

11. The component of claim 4 in which the light diffusing layer comprises a dome or elongated dome shape.

18. A light emitting device, comprising:

> at least one solid-state light emitter operable to generate excitation light; and
>
> a wavelength conversion component comprising:
>
> > at least one photoluminescence material; and
> >
> > a light scattering material, wherein the light scattering material has an average particle size that is selected such that the light scattering material will scatter excitation light from the at least one solid-state light emitter relatively more than the light scattering material will scatter light generated by the at least one photoluminescence material,
>
> wherein the wavelength conversion component is configured such that in operation a portion of the excitation light comprising blue light having a wavelength of greater than or equal to 440 nm is emitted through the wavelength conversion component to contribute to a final visible emission product;
>
> wherein the light scattering material scatters the blue light at least twice as much as light generated by the at least one photoluminescence material.

19. The device of claim 18, wherein the light emitting device is selected from the group consisting of: downlights, light bulbs, 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.

20. The device of claim 18 in which the average particle size of the light scattering material is selected to improve an OFF state white appearance of the light emitting device.

23. The device of claim 18, wherein the light scattering material has an average particle size that is less than about 150 nm.

24. The device of claim 18 in which the wavelength conversion layer and the light diffusing layer comprises planar shapes.

25. The device of claim 18 in which the light diffusing layer comprises a dome or elongated dome shape.

28. 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
>
> > at least one photoluminescence material; and
> >
> > a light scattering material, wherein the light scattering material has an average particle size that is selected such that the light scattering material will scatter excitation light from the one or more solid-state light emitters relatively more than the light scattering material will scatter light generated by the at least one photoluminescence material,

wherein the wavelength conversion component is configured such that in operation a portion of the excitation light comprising blue light having a wavelength of greater than or equal to 440 nm is emitted through the wavelength conversion component to contribute to a final visible emission product;

wherein the light scattering material scatters the blue light at least twice as much as light generated by the at least one photoluminescence material.

Savant Technologies LLC d/b/a GE Lighting, Elong International USA Inc. and Xiamen Longstar Lighting Co. Ltd. ("Petitioners") request *inter partes* review of U.S. Patent No. 8,614,539 ("the '539 patent") (EX1101) under 35 U.S.C. § 311 *et seq.* and 37 C.F.R. Part 42. Petitioners' request is supported by the testimony of Professor Alan Doolittle (EX1102; EX1103), and other corroborating exhibits. This petition shows there is a reasonable likelihood that at least one of claims 1-11, 18-20, 23-25, and 28 of the '539 patent is unpatentable for failure to satisfy pre-AIA 35 U.S.C. § 103.

I. RELATIONSHIP TO PENDING PETITIONS FOR *INTER PARTES* REVIEW OF RELATED PATENT

The '539 patent and U.S. Patent No. 8,604,678 ("the '678 patent") are both continuations-in-part of the same priority applications. Savant filed a prior petition requesting *inter partes* review of the '678 patent on August 26, 2024 (IPR2024-01357). On December 9, 2024, Elong filed a joinder petition (IPR2025-00260) and Savant and Elong filed a petition (IPR2025-00258) challenging newly-asserted claims 11 and 12 and related claims 13 and 14 of the '678 patent. On March 5, 2025, the Board instituted review in IPR2024-01357.

Feit recently amended its complaint to assert the '539 patent against Savant. The only substantial difference between the independent claims of the '678 patent and the independent claims of the '539 patent is that the '539 patent claims all require that “the light scattering material scatters the blue light at least twice as much as light generated by the at least one photoluminescence material.” This same requirement is found in claims 11-14 of the ’678 patent. Accordingly, the prior art and arguments relied on by this petition are substantially similar to the prior art and arguments relied on in the petitions challenging the ’678 patent.

For that reason, among others, the Board should exercise its discretion to institute IPR based on this petition, and Petitioners suggest coordination of this IPR together with the IPRs challenging the ’678 patent.

II. INTRODUCTION

Today’s LED light bulbs use LED light sources made up of LEDs that generate blue light and phosphors that convert some of that blue light to longer wavelengths so that the combined light appears white. (EX1102, ¶¶44-52, 65-69.) When off, such white-light LED light sources are yellow in color. (*Id.*) The challenged claims are generally directed to white-light LED light sources that have an outer layer containing titanium dioxide particles (“TiO_2 particles,” i.e., white pigment particles) so that when the LED light source is off, it will appear less yellow and more white. During prosecution, the applicants distinguished the examiner-cited prior art because it did not disclose a white-light LED light source using a blue LED. The applicants never informed the Examiner that the use of a light diffusing layer containing TiO_2 particles in a white-light LED light source using a blue LED was disclosed in the prior art. (EX1104.) Indeed, the applicants borrowed a prior art figure to teach this feature in their specification.

The use of a light diffusing layer containing TiO_2 particles with a white-light LED light source using a blue LED was known for years before the earliest filing date of the ’539 patent. (EX1102, ¶¶53-64, 70-74.) There are numerous prior art references that disclose the use of TiO_2 with white-light LED light sources using blue LEDs. (*See, e.g.*, EX1105 (Basin-2007), EX1107 (Krummacher), EX1110 (Shimizu), EX1108 (Stokes).) One such prior art reference serves as the basis for Figure 10 of the ’539 patent, which seems to have been appropriated from DuPont marketing materials for TiO_2. (EX1112, p.4, fig.4; EX1113, p.8, fig.7.)

Krummacher renders obvious the challenged claims together with secondary references teaching well-known implementation details of such white-light LED light sources, including the use of sub-micron TiO_2 particles, the wavelength of blue light, and the use of silicone as a binder, all of which are well-known in the art as shown by Shimizu and Stokes.

Accordingly, *inter partes* review should be instituted and the challenged claims canceled.

A. U.S. Patent No. 8,614,539

The ’539 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. (*See also* EX1102, ¶¶75-78.) The ’539 patent claims broadly cover a white-light LED light source with a light diffusing layer containing TiO_2 particles that scatter more light from the photoluminescence material than light from the blue LED. (*See, e.g.*, EX1101, claim 1.)

B. Prosecution History

The ’539 patent issued from U.S. Pat. Appl. No. 13/273,215. (EX1104.) 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. (*See also* EX1102, ¶¶79-82.)[1]

During prosecution, the only prior art reference applied by the Examiner against the independent claims for the light scattering material 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 (EX1104, pp.161-65), and (2) indeed, taught an ultraviolet (i.e., not visible light) LED chip unsuitable for a white-light LED light source (EX1104, pp.259-62).

With respect to the ***first*** distinction, the applicants amended the claims to

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[1] As the art applied herein predates the earliest alleged filing date, the legitimacy of the priority claim need not be assessed.

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 yellow light emitted by phosphors that are excited by the blue light (and appear yellow when the LED light source is off). (EX1104, p.151.) 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 blue light generated by a blue-light LED chip. (EX1104 p.253.) That amendment is underlined twice below.

1. A wavelength conversion component for a light emitting device comprising:

> at least one photoluminescence material; and
>
> a light scattering material, wherein the light scattering material has an average particle size that is selected such that the light scattering material will scatter excitation light from a radiation source relatively more than the light scattering material will scatter light generated by the at least one photoluminescence material;
>
> wherein the wavelength conversion component is configured such that in operation a portion of the excitation light comprising blue light having a wavelength of greater than or equal to 440 nm is emitted through the wavelength conversion component to contribute to a final visible emission product;
>
> wherein the light scattering material scatters the blue light at least twice as much as light generated by the at least one photoluminescence material.

The applicants convinced the Examiner that it would not have been obvious to use light scattering material with a phosphor-converted white-light-emitting light source utilizing blue LEDs. (EX1104, p.406 (citing pp.395-96).) The applicants never informed the Examiner that the use of a TiO_2-containing light diffusing layer in such a white-light LED light source was known and disclosed in the prior art.

C. Level of Skill in the Art

1. Qualifications of a POSA

The ’539 patent describes the alleged invention as “relat[ing] to solid-state light emitting devices that use a … phosphor wavelength conversion component to generate a desired color of light.” Accordingly, a POSA 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 ’539 patent and the prior-art references discussed herein. Moreover, the prior art reflects the level of skill at the time of the claimed invention. *See Okajima v. Bourdeau*, 261 F.3d 1350, 1355 (Fed. Cir. 2001). (*See also* EX1102, ¶¶38-42.)

2. Technological Background

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

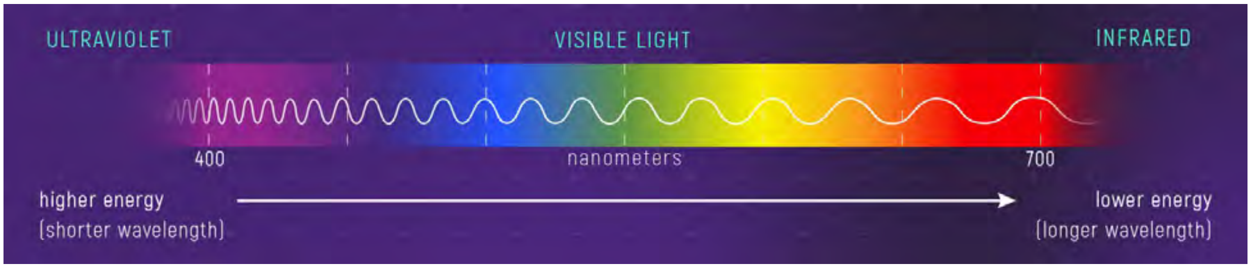
As reflected in the Background of the ’539 patent, the development of high-efficiency blue-light LED chips led to white-light LED light sources that could replace fluorescent and incandescent light sources. (EX1101, 1:30-46; *see also* EX1102, ¶¶65-69.) Citing Shimizu-APA, the ’539 patent discussed the structure and operation of white-light LED sources thusly:

> 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.

(EX1101, 1:38-46.)

As described in Shimizu and elsewhere, LED chips convert electricity to light very efficiently, but they emit monochromatic light in a relatively narrow wavelength range. (*See* EX1102, ¶¶50, 66.)

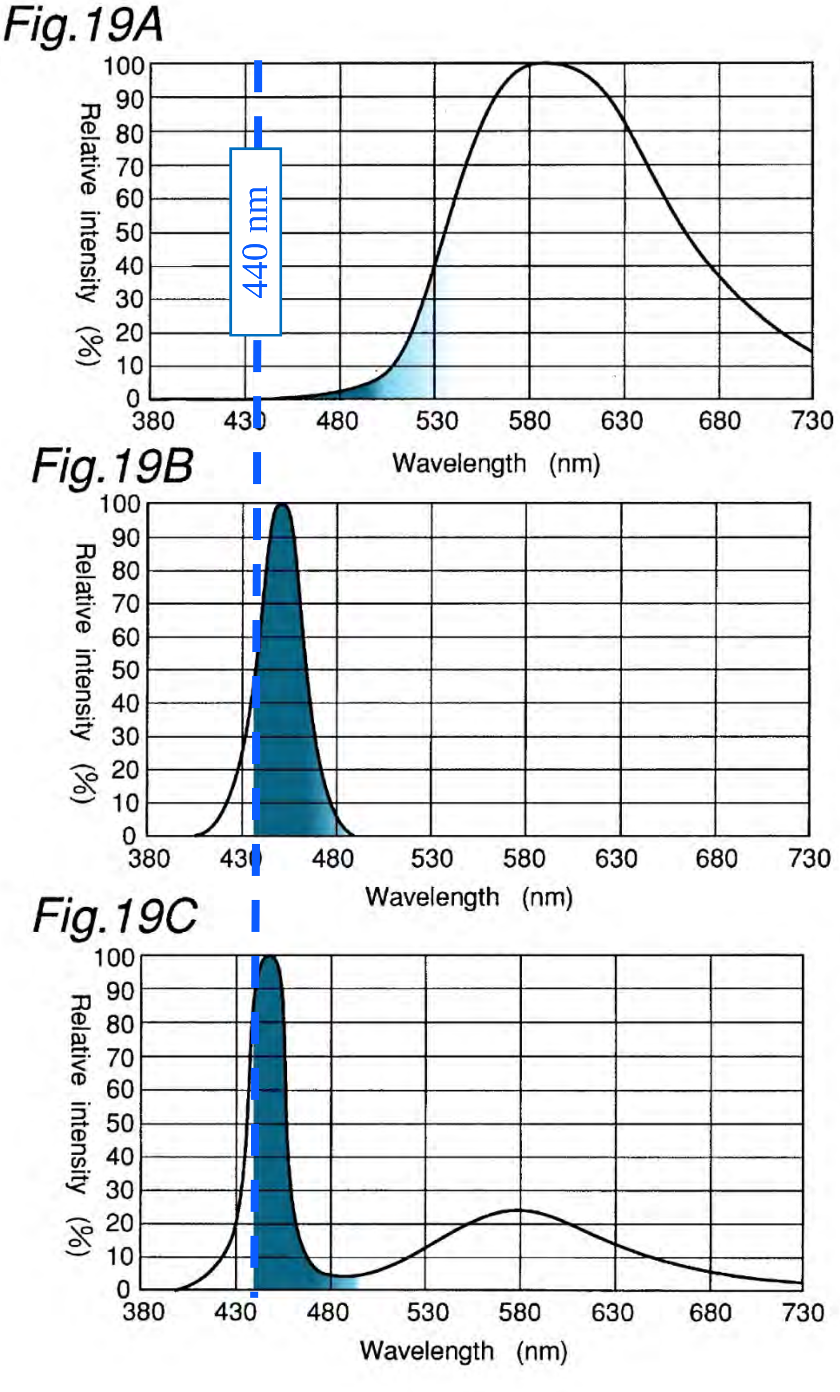
Phosphors convert light by absorbing light at one wavelength and emitting it at another. Blue light is at the higher frequency end of the visible light spectrum (e.g., ~440 nm), and has higher energy than other visible light. Phosphors convert higher energy blue light to lower energy light, such as yellow light. (EX1102, ¶67.)



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

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 blue light emitted by the LED chip. In 1999, Shimizu demonstrated this through three charts (Figures 19A-C) that have been annotated below to indicate 440 nm (as specified in the claims of the ’539 patent) and shade the visible blue light range from 440 nm to about 490 nm. (EX1102, ¶68.)

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 LED chip, which is a has a peak at 450nm. Finally, Figure 19C shows the relative intensity of the white light that combines the contribution at 450nm of the blue light emitted by the LED chip and not absorbed by the phosphors with the higher energy light generated by the phosphors. (EX1102, ¶69.)



Shimizu-APA, Annotated Figures 19A-19C

b. White-light LED light sources were improved with a TiO_2-containing light diffusing layer

By 2010, the earliest filing date of the ’539 patent, it was well-known to use a light diffusing layer, such as a layer containing TiO_2 particles, in white-light LED light sources to diffuse light and to obtain an off-state white appearance in the LED package. (*See* EX1102, ¶¶70-74.)

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 yellow-to-orange appearance. In one application, blue LEDs mounted on a substrate are covered in phosphor-containing silicone in order to mimic the appearance of the filament in a traditional incandescent light bulb. Such LED “filaments” appear yellow when unlit (off) due to the presence of the phosphor coating. (EX1102, ¶71.)

Once white-light LED light sources were developed and employed in LED light bulbs and other lighting devices, artisans realized that some consumers found the yellow color of the phosphor layer in the off-state undesirable. To improve that appearance, artisans used a light diffusing layer containing TiO_2 particles to obscure the yellow body color of the phosphor converter and make it appear whiter when turned off. (*E.g.*, EX1105, ¶[0004]; EX1107, ¶[0004]; EX1119, 1:28-35 (“in many applications a colored appearance of a light source in the off-state is undesired, techniques have been developed to produce LED based illumination devices having a neutral, e.g. white or whitish, appearance in the off-state”); EX1120, 5:29-30 (“it is this yellowish appearance of the pc-LED under ambient lighting conditions that is disturbing in many application areas”).) This knowledge in the art is reflected in the prior art references discussed below. (EX1102, ¶¶73-74.)

c. Sub-micron particles of TiO_2 were known to preferentially scatter blue light

The prior art also disclosed the use of TiO_2 particles smaller than a micron to scatter relatively more blue light than light generated by the photoluminescence material, including TiO_2 particles that would scatter blue light at least twice as much as light generated by the photoluminescence material.[2]

In May 1997, two DuPont researchers, Erik S. Thiele and Roger H. French, presented the paper “Light-Scattering Properties of Representative, Morphological

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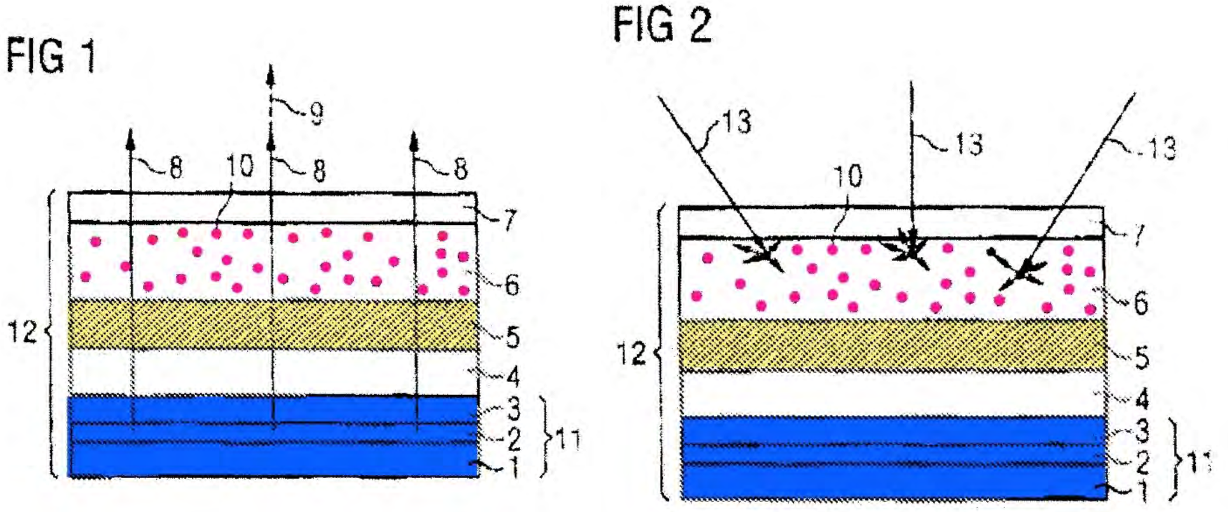
[2] As in the ’539 patent, these prior art disclosures are all based on a graph of a theoretical model. As discussed here, unlike the ’539 patent, the prior art acknowledges the theoretical nature of light scattering by sub-micron particles of TiO_2 and attributes the model to DuPont.

Rutile Titania Particles Studied Using a Finite-Element Method." (EX1115.) The paper proposed a theoretical model of the light-scattering properties of certain types of TiO_2 particles. (*Id.*; EX1102, ¶¶75-77.)

As discussed below, Stokes (EX1108) provides a figure labeled "prior art" (fig. 6, shown below) that uses the DuPont finite-element method to "illustrate[] the relationship between the particle diameter and the wavelength of the scattered light for Ti-Pure® rutile TiO_2 particles made by DuPont." (*Id.*, 7:7-9; *see also* EX1102, ¶¶78-79.) Stokes applies this information to a white-light LED light source to suggest preferentially scattering "blue radiation (i.e., such as that emitted by a blue emitting LED)" as compared to "green or red (or for that matter yellow) radiation (i.e., such as that emitted by the phosphor or dye)." (*Id.*, 7:1-26.) Numerous other references disclosed a similar graph attributed to DuPont. (*See, e.g.,* EX1112; EX1113; EX1123; EX1124; *see also* EX1102, ¶¶80-83.) The DuPont model was well-known in the prior art.

D. Summary of Asserted References

1. Krummacher (Pub. No. US 2008/0079015; EX1107)



Krummacher, Annotated Figures 1-2

U.S. Patent Publication No. US 2008/0079015 A1 to Krummacher, filed on September 18, 2007, and published on April 3, 2008 (EX1107), is prior art under pre-AIA 35 U.S.C. § 102(b). (*See also* EX1102, ¶¶98-100.)

As shown in the annotated figures above, Krummacher 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), and a cladding layer (7). (EX1107, ¶¶[0033], [0036], [0038], [0039].) 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-appearing light. (EX1107, ¶¶[0031],

[0036].) Figure 2 shows that the light-diffusing layer (6) (containing, for example, TiO_2 particles) obscures any yellow light color from the phosphor layer (5) when the light source is in the OFF state. (EX1107, ¶¶[0031], [0039], [0041].)

2. Stokes (Pat. No. 6,791,259; EX1108)

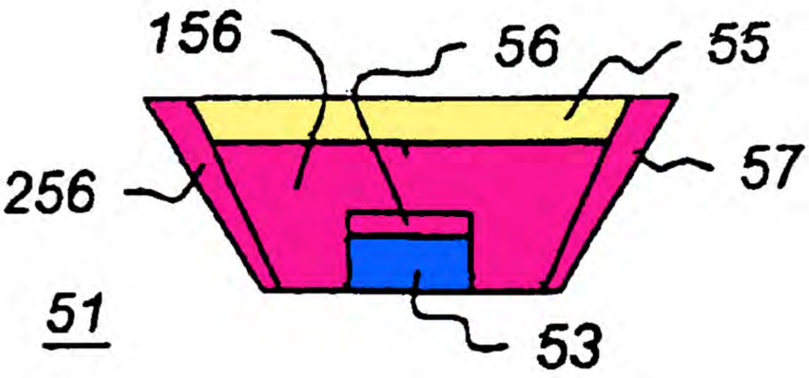


fig 7

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. (EX1108.) Stokes is prior art under pre-AIA 35 U.S.C. § 102(b). (*See also* EX1102, ¶¶101-03.)

Stokes discloses a white-light LED lamp with light diffusing layers that may comprise TiO_2 particles (56, 156, and 256 in the annotated image above).

(EX1108, 7:51-52.) Significantly, the “prior art” Figure 6 of Stokes (shown below) is essentially the same as Figure 10 of the ’539 patent. Stokes attributes the data, which relates to the relative scattering of different size TiO_2 particles on red, green, and blue light, to DuPont. (EX1108, 7:7-26, [56] (citing “DuPont Ti-Pure Titanium Dioxide Web Page,” visited Aug. 3, 2000).)

Stokes was not before the Examiner during prosecution of the ’539 patent. Unlike Stokes, the applicants did not label Figure 10 of the ’539 patent as prior art.

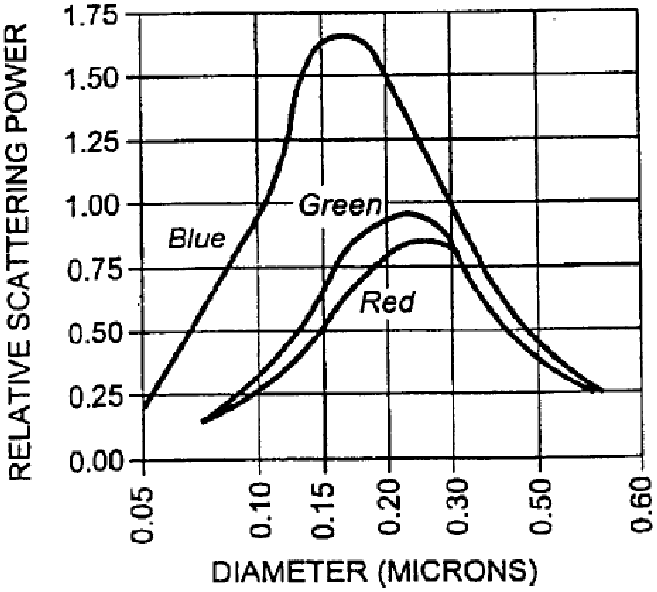
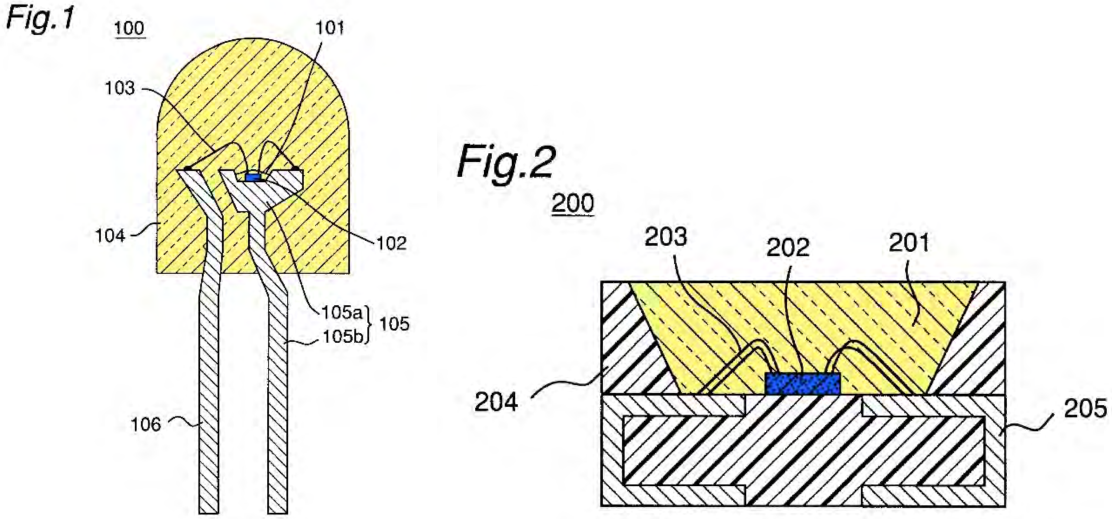


fig. 6

(PRIOR ART)

Stokes (EX1108).

3. Shimizu (Pat. No. 6,069,440; EX1110) and Shimizu-APA (Pat. No. 5,998,925; EX1109)



Shimizu, Annotated Figures 1-2

U.S. Patent Nos. 5,998,925 (“Shimizu-APA”) (EX1109) and 6,069,440 (“Shimizu”) (EX1110), a divisional of Shimizu-APA, share a common disclosure and are prior art under pre-AIA 35 U.S.C. § 102(b). Shimizu-APA is admitted prior art to the ’539 patent. (EX1101, 1:34-38.) Shimizu is incorporated by reference into Stokes. (*See also* EX1102, ¶¶104-07.)

Shimizu discloses a white-light LED light source that uses a blue LED and a diffusing layer to improve its OFF-state color, 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 …. That is, the fluorescent material absorbs blue component

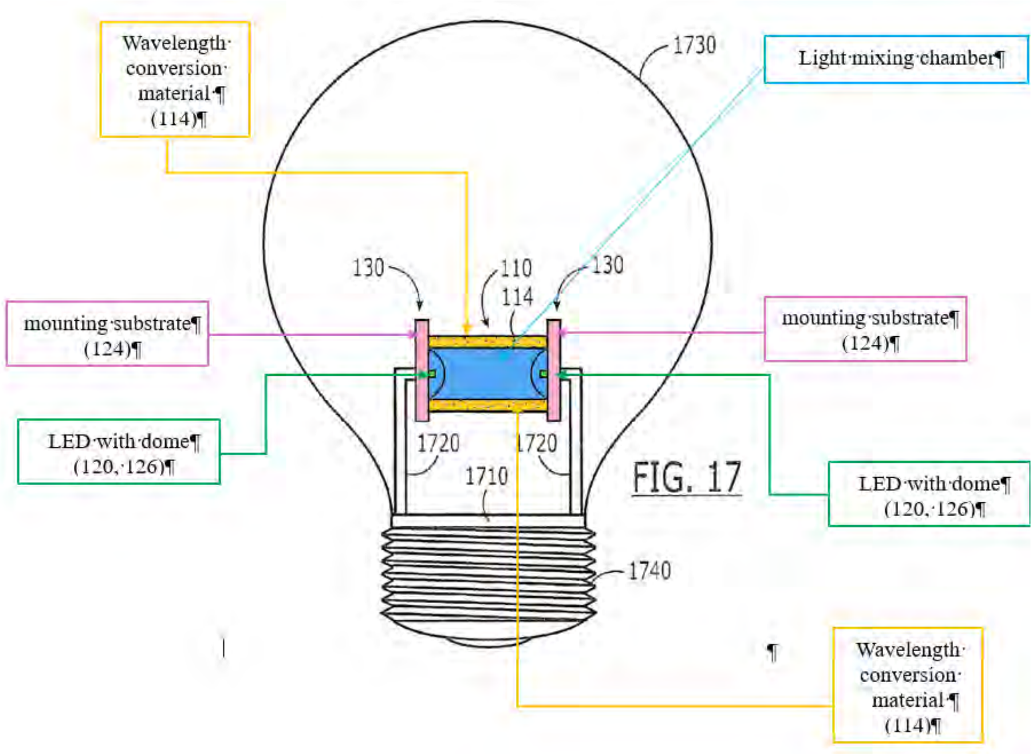
> of extraneous light and emits light thereby to [appear] yellow. However, the **dispersant** contained in the molding material gives **milky white color** to the molding material and the coloration agent renders a desired color. **Thus the color of the fluorescent material will not be recognized by the observer.**

(EX1110, 17:25-35 (emphasis added).)

Shimizu further states that the disclosed white-light LED light source can be used in a wide variety of applications including general lighting applications. In particular, Shimizu discloses use of its white-light LED in buoys for harbors and ports, as well as outdoor use in signage and illumination for expressways. (EX1110, 31:11-16.)

The ’539 patent applicants did not inform the Examiner that Shimizu disclosed a white-light LED light source with the claimed light scattering material when discussing it in the Background section of their ownapplication.

4. Hussell (Pub. No. US2010/0124243; EX1111)



Hussell, Annotated Figure 17

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). (EX1111) (*See also* EX1102, ¶¶108-09.)

Hussell discloses a "semiconductor light emitting apparatus" that leverages a "wavelength conversion tube" to obtain "high efficiency white light production." (EX1111, Abstract, ¶[0038].) In the embodiment depicted in Figure 17, 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." (EX1111, ¶[0052].)

III. STANDING CERTIFICATION (37 C.F.R. § 42.104(a))

The '539 patent is available for *inter partes* review. Petitioners are not barred or estopped from requesting *inter partes* review on the identified grounds.

IV. IDENTIFICATION OF CHALLENGE (37 C.F.R. § 42.104(b))

Petitioners request review of claims 1-11, 18-20, 23-25, and 28 of the '539 patent under 35 U.S.C. § 311. The grounds are as follows.

Ground	Claims	Description
1	1-11, 18-20, 23-25	Obvious over Krummacher in view of Stokes and Shimizu
2	18 and 28	Obvious over Hussell in view of Krummacher, Stokes, and Van Woudenberg[3]

V. CLAIM CONSTRUCTION

Claims should be understood according to their ordinary and customary meaning as understood by a POSA at the time of the invention considering the language of the claims, the specification, and the prosecution history of record. 37 C.F.R. §42.100; *Phillips v. AWH Corp.*, 415 F.3d 1303, 1312-14 (Fed. Cir.

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[3] International Patent Publication No. WO 2008/044171 A2 to Van Woudenberg *et al.*, published April 17, 2008, is prior art under pre-AIA 35 U.S.C. § 102(b).

2005) (*en banc*). The Board need construe claims only to the extent necessary to resolve a patentability controversy. *Nidec Motor Corp. v. Zhongshan Broad Ocean Motor Co. Matal*, 868 F.3d 1013, 1017 (Fed. Cir. 2017). Petitioners submit that no construction should be necessary to institute this petition. (*See also* EX1102, ¶¶92-95.)

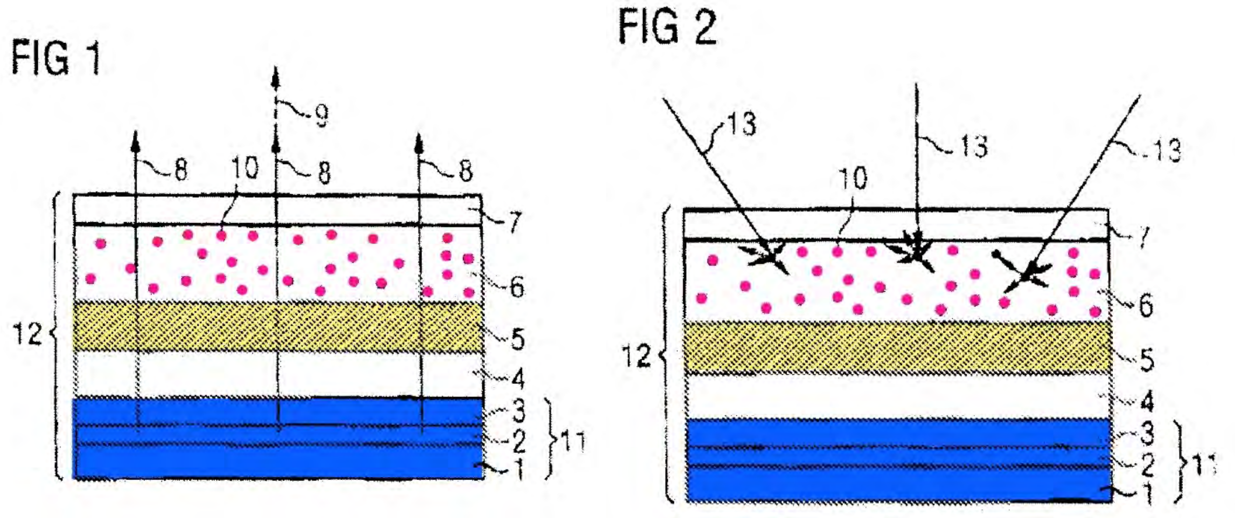
Patent Owner has never requested that the term "light diffusing layer" be construed either in related IPRs (IPR2024-01357, POPR at 37) or in any of the district court actions (EX1134, EX1135, EX1136). Moreover, Patent Owner interprets the term broadly in its infringement contentions. (EX1137; EX1138; EX1139.) The term should be given its plain and ordinary meaning.

Petitioners reserve the right to argue different constructions in any other actions involving the '539 patent.

VI. [GROUND 1] Claims 1-11, 18-20, 23-25 are rendered obvious by Krummacher in view of Stokes and Shimizu

Krummacher discloses every element of the independent claims except which particle sizes were known to preferentially scatter blue light and the specific wavelength of the blue light emitted by the LED chip. But light diffusing layers that preferentially scatter blue light and LED chips emitting blue light at greater than or equal to 440 nm were well known in the art as evidenced by Stokes and

Shimizu (incorporated by reference in Stokes). Thus, Krummacher in view of Stokes and Shimizu renders obvious all of the challenged claims.



Krummacher, Annotated Figures 1-2

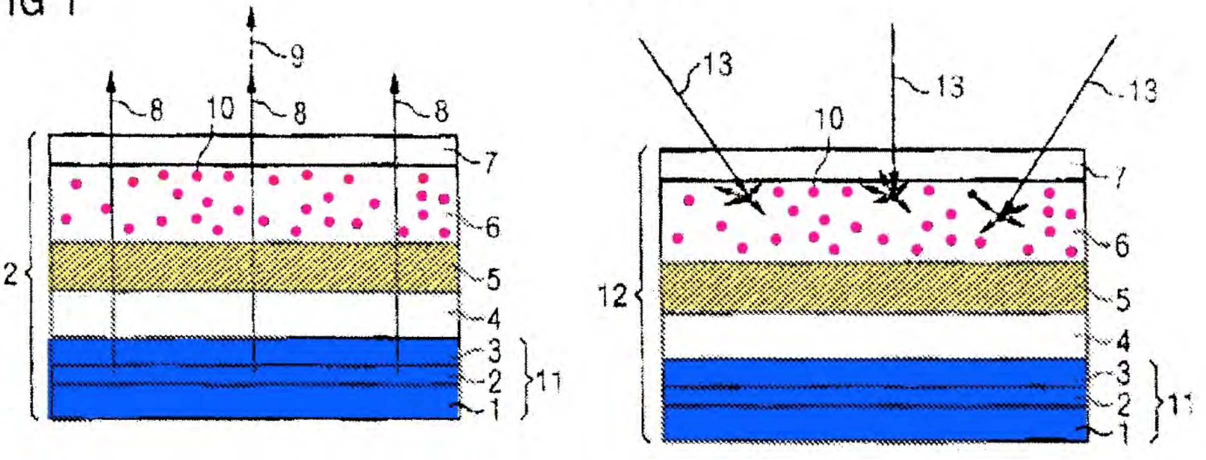
Independent Claim 1: Wavelength Conversion Component

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

The preamble is not limiting and is entitled to no patentable weight.

Nonetheless, Krummacher discloses a wavelength conversion component. As shown in the annotated images below, Krummacher discloses in Figures 1 and 2 an “optoelectronic component” that includes a layer sequence 11, a luminescence conversion layer 5, and light-scattering translucent layer 6.” (EX1107, ¶¶[0034], [0038].)

FIG 1 FIG 2



Krummacher, Annotated Figures 1-2

The combination of the luminescence conversion layer and the light-scattering translucent layer comprise the wavelength conversion component. (*See also* EX1102, ¶¶110-14.)

[a] at least one photoluminescence material

Krummacher discloses 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, highlighted in yellow.

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." (EX1107, ¶[0037]; *see also id.* ¶[0023].) Krummacher describes the operation 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.

(EX1107, ¶[0036].) A POSA would understand YAG:Ce to be present as particles in the wavelength conversion layer for embedding in silicone or epoxy (EX1107, ¶[0037]), as taught by Stokes and Shimizu, and that such particles are "photoluminescence materials" because they absorb blue light (high energy) and radiate light at a lower energy state. (EX1102, ¶95.)

Accordingly, Krummacher in view of Stokes and Shimizu discloses a wavelength conversion layer comprising particles of at least one photoluminescence material. (*See also* EX1102, ¶¶115-18.)

[b] a light scattering material

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.

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.

(EX1107, ¶[0038].) Krummacher further discloses the light diffusing layer containing TiO_2 particles. (EX1107, ¶[[0039].)

Accordingly, Krummacher discloses a light diffusing layer comprising particles of a light scattering material. (*See also* EX1102, ¶¶119-21.)

[c] wherein the light scattering material has an average particle size that is selected such that the light scattering material will scatter excitation light from a radiation source relatively more than the light scattering material will scatter light generated by the at least one photoluminescence material

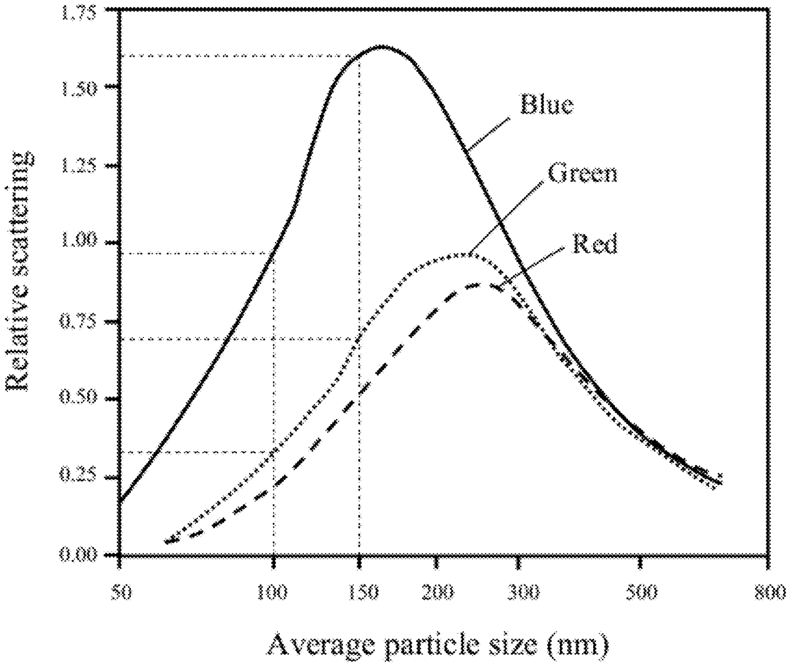
Krummacher in view of Stokes discloses that the light scattering material has an average particle size that is selected such that the light scattering material will scatter excitation light from a radiation source relatively more than the light scattering material will scatter light generated by the at least one photoluminescence material.

Consistent with claim 1[c], Stokes discloses:

> 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.

(EX1108, 7:1-4.)

As discussed in detail above, Figure 10 of the ’539 patent is essentially the same as graphs found in the prior art, including Figure 6 of Stokes, that were derived from the DuPont model described in the background (Section II.C.2.c) above. In particular, the graphs show the relative scattering power of TiO_2 based on particle size for different colors of light. (EX1102, ¶¶122-23.)



’539 Patent, Figure 10

Krummacher discloses a light scattering material with TiO_2 particles “preferably having a radius of between 50 nm inclusive and 1000 nm inclusive.” (EX1107, ¶[0039].) According to the DuPont model, TiO_2 particles of such a size generally scatter more blue light (e.g., excitation light) than red or green light (e.g., light emitted by the phosphor). (EX1102, ¶124.) Accordingly, Krummacher renders obvious this claim element by literally disclosing the selection of average particle sizes that preferentially scatter blue light.

To the extent that the claim language “an average particle size that is selected such that [it preferentially scatters blue light]” requires an average particle size selected for that reason (rather than an average particle size that leads to that outcome), this claim element is rendered obvious by Stokes. (EX1102, ¶125.) Stokes explicitly discloses the selection of an average particle size "such that the particles preferentially scatter blue … LED light as compared to yellow … light from the luminescent material." (EX1108, 7:1-4.)

A POSA would have had reason to use such a basis for selecting average particle size as taught by Stokes. (EX1102, ¶¶126-28.) For example, Stokes discloses:

> [The relevant] 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.

(EX1108, 7:17-26.)

Thus, a POSA would have been motivated to apply this principle to Krummacher, because it would increase the conversion of blue light to yellow light and improve the uniformity of the light source. (EX1102, ¶128.) Conversion of blue light to yellow light is improved by maximizing the scattering of blue light.

(*Id.*) Uniformity is improved by preferentially scattering the concentrated light from the blue-light LED chip instead of the diffuse light emitted by the phosphor. (*Id.*)

A POSA would have had a reasonable expectation of success applying this principle to Krummacher, because the relevant particle size range includes the range disclosed by Krummacher. A POSA would have recognized selecting an average particle size as a design decision to be made based on a number of factors, including the light scattering properties of the particles, that was well within the ordinary skill of the art. (EX1102, ¶129.)

Accordingly, Krummacher in view of Stokes discloses that the light scattering material has an average particle size that is selected such that the light scattering material will scatter excitation light from a radiation source relatively more than the light scattering material will scatter light generated by the at least one photoluminescence material. (*See also* EX1102, ¶¶122-30.)

[d] 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

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.

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

(EX1107, ¶[, ¶[0003].)

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. (EX1102, ¶131-33.) In addition to being a white-light emitting LED device, Krummacher discloses that "the optoelectronic component is for example an LED or an LED module 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." (EX1107, ¶[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." (*Id.*, ¶¶[0031]-[0032].) "The active layer 2 can in particular comprise a nitride compound semiconductor material, for example $In_xAl_yGa_{1-x-y}$ where 0≤x≤1 and x+y≤1." (*Id.*, ¶[0032].)

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 and Shimizu. (EX1102, ¶134.) Stokes and Shimizu both disclose white-light LED light sources with blue-light LED chips. 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. (EX1110 at 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" (EX1108 at 4:37-40) along with “blue emitting LEDs having a peak emission wavelength of λ=450 nm” or “peak emission wavelength of λ=480 nm” (*Id.,* at 6:62-67).

A POSA would have been motivated to use a blue-light LED chip like that disclosed by Stokes and Shimizu in a conventional white-light LED light source called for by Krummacher. (EX1102, ¶135.) Shimizu, in particular, is cited by both the ’539 patent and the prior art as an example of a conventional white-light LED light source containing a blue-light LED. Thus, it would have been obvious to look to Stokes and Shimizu 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, doing so would have been the simple substitution of one known element for another to obtain predictable results and well within the skill of a POSA. (EX1102, ¶¶135-36.)

Accordingly, Krummacher in view of Stokes and Shimizu discloses or suggests all elements in this limitation.

[e] wherein the light scattering material scatters the blue light at least twice as much as light generated by the at least one photoluminescence material.

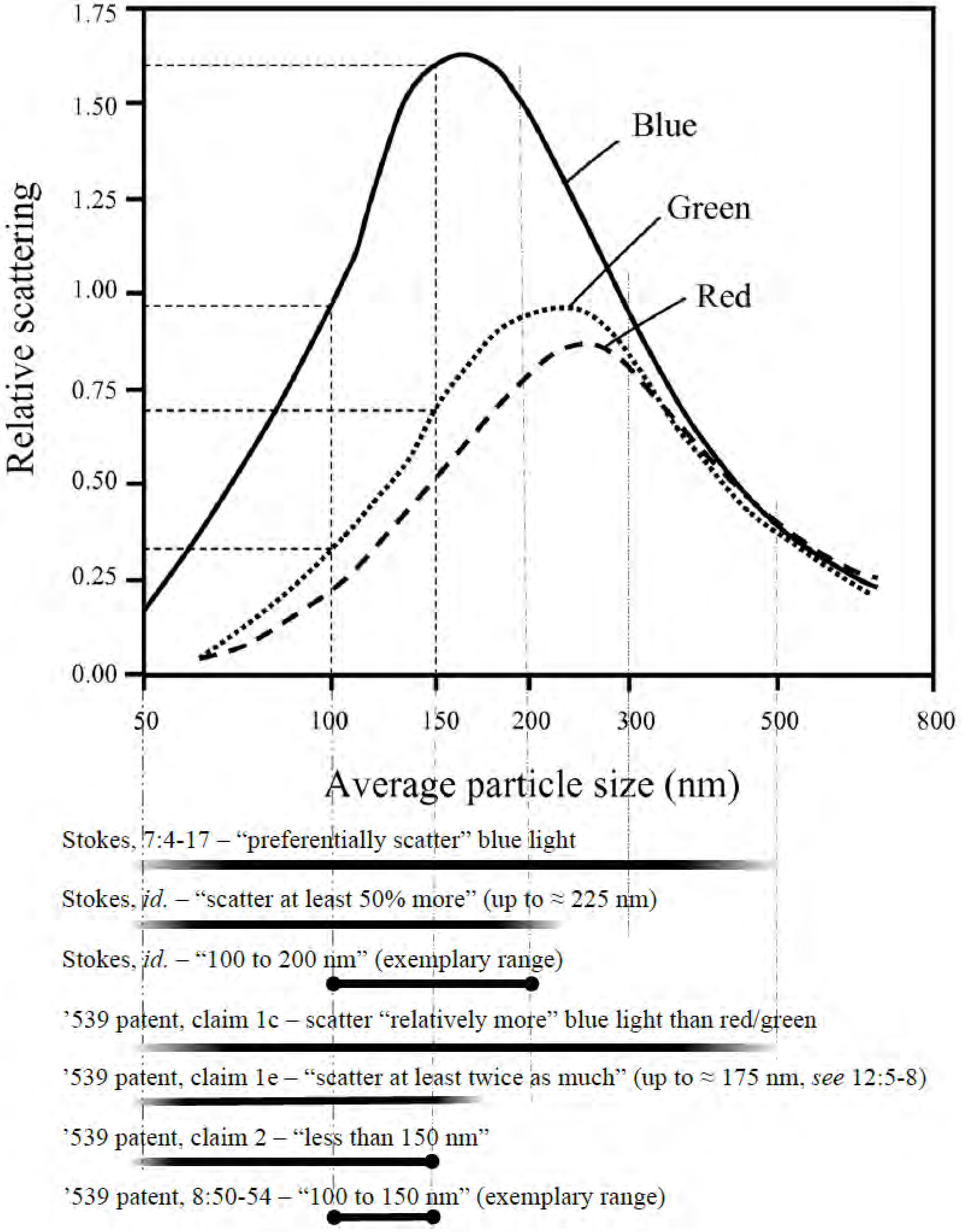
Krummacher in view of Stokes discloses the light scattering material scatters the blue light at least twice as much as light generated by the at least one photoluminescence material.

As discussed above, Krummacher in view of Stokes renders obvious claim element 1c. Claim element 1e only further requires that the "relatively more" of claim element 1c be "at least twice as much." The '539 patent discloses no particular significance to "at least twice as much," which represents a straightforward narrowing of the claimed average particle size range from claim element 1c so that it extends only up to around 175 nm, with the '539 patent disclosing a preferred range of 0.10 to 0.15 microns (100 nm to 150 nm). (EX1101, 11:65-12:2; *see also* EX1102, ¶137.)

> A *prima facie* case of obviousness typically exists when the ranges of a claimed composition overlap the ranges disclosed in the prior art." … "[I]n the absence of evidence indicating that there is something special or critical about the claimed range, an overlap suffices to show that the claimed range was disclosed in—and therefore obvious in light of—the prior art." … "[A]bsent a reason to conclude otherwise, a factfinder is justified in concluding that a disclosed range does just that—discloses the entire range."

Almirall, LLC v. Amneal Pharms. LLC, 28 F.4th 265, 273 (Fed. Cir. 2022) (citations omitted).

Accordingly, claim element 1e is *prima facie* obvious for the same reasons that claim element 1c is obvious. The annotated Figure 10 shown on the next page compares the ranges claimed in the ’539 patent to the ranges disclosed by Stokes. (EX1102, ¶¶138-39.)



Annotated Figure 10

Moreover, consistent with claim element 1e, Stokes discloses the routine optimization of average particle size[4] to preferentially scatter blue light. (EX1102, ¶¶140-41.) In particular, as reflected in the annotated Figure 10 of the ’539 patent above, Stokes explicitly discloses selecting an average particle size that scatters excitation light at least 1.5 times as much as light emitted by the phosphor and gives an exemplary range of 0.10 to 0.20 microns (100 to 200nm). That is:

> 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

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[4] Consistent with the DuPont model being theoretical, the DuPont graphs and related prior art such as Stokes are based on exact particle size, not the more practical average particle size. A broad distribution of particle sizes may have the same average particle size as a narrower distribution while having very different scattering properties. Given that the average particle size of a set of exact theoretical particles is the same as the exact particle size, the distinction does not matter here. (EX1102, ¶140 n.6.)

> 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).

(EX1108, 7:4-17; *see also* EX1124 (Toquin) at ¶¶[0080]-[0081] (disclosing preferentially scattering blue light using particles of approximately 150 nm).)

In other words, Krummacher discloses the use of particles with "at least a 50% greater scattering power for blue radiation," which includes the particles that that "scatter[] the blue light at least twice as much." (*See* EX1102, ¶142.) Thus, as illustrated in the annotated Figure 10 above, the range of average particle size disclosed by Stokes based on preferentially scattering blue light overlaps and entirely encompasses the similar range required by this claim term, rendering it obvious. (*Id.*)

Neither Stokes nor the '539 patent assign any particular significance to the disclosed ranges, other than that they are based on preferentially scattering blue light. (EX1102, ¶143.) The values recited for the endpoints of both ranges appear to be based on rough estimations in reading DuPont's chart. (*Id.*) And the difference between the disclosed ranges is one of degree rather than kind. (*Id.*) As discussed above, a POSA would have recognized selecting an average particle size as a design decision to be made based on a number of factors, including the light scattering properties of the particles, and well within the skill of the art. (EX1102, ¶144.) For example, a POSA would weigh the benefits of maximizing the ratio of blue light scattered compared to yellow light with the potential downsides, including not maximizing blue light scattered, decreasing light output due to increased internal reflection, and limiting the commercially-practical options for rutile TiO2 by requiring a narrower range of average particle size. (*Id.*)

Accordingly, Krummacher in view of Stokes discloses all elements of this limitation.

Krummacher in view of Stokes and Shimizu thus renders claim 1 obvious as a whole.

Claim 2: Average Particle Size Less Than 150 nm

Claim 2 requires "[t]he component of claim 1, wherein the light scattering material has an average particle size that is less than about 150 nm."

As discussed above, Krummacher in view of Stokes and Shimizu renders obvious claim 1. Claim 2 claims a range of average particle sizes with the lower bound of claim element 1c ("relatively more") and the upper bound of the exemplary range disclosed by the '539 patent (150 nm). The '539 patent discloses no particular significance to any of these ranges. (EX1102, ¶¶147-148.) With respect to the 150 nm bound, the '539 patent simply states:

> Light diffractive particles within the light diffusing layer are selected to have a size such that the particles will scatter blue light generated by the LED relatively more than they will scatter light generated by a wavelength conversion layer, e.g., where the particles have an average particle size that is less than about 150 nm.

(EX1101, 25:57-62.)

As discussed in detail above, consistent with claim 2, Stokes discloses the routine optimization of average particle size to preferentially scatter blue light and discloses a preferred range of about 100 to 200 nm. (*See, e.g.*, EX1108, 7:4-17; EX1102, ¶149.) Thus, as shown in the annotated Figure 10 above, Stokes discloses ranges of average particle size that encompass and overlap the claimed range of average particle sizes—including the 100 to 150 nm range that is described as advantageous (EX1101, 8:53-54) and essentially the same as the range required by claim element 1e—rendering claim 2 obvious. (EX1102, ¶149.) As discussed above, these ranges have no particular significance, other than that they are based on preferentially scattering blue light. (*Id.*) As also discussed above, a POSA would have recognized selecting an average particle size as a design decision to be made based on a number of factors, including the light scattering properties of the particles, and well within the skill of the art. (*Id.*)

Krummacher in view of Stokes and Shimizu thus teaches all of the elements of claim 2 and renders claim 2 obvious as a whole.

Claim 3: Light Scattering Material is TiO_2

Claim 3 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."

As discussed above, Krummacher in view of Stokes and Shimizu 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. (EX1107, ¶[[0039] ("Particularly suitable are particles of TiO2 or Al2O3, preferably having a radius of between 50 nm inclusive and 1000 nm inclusive.").)

Krummacher in view of Stokes and Shimizu thus teaches all of the elements of claim 3 and renders claim 3 obvious as a whole. (*See also* EX1102, ¶¶151-53.)

Claim 4: Wavelength Conversion and Diffusing Layers

Claim 4 requires "[t]he component of claim 1 wherein the at least one photoluminescence material is located in a wavelength conversion layer and the light scattering material is located in a diffusing layer."

As discussed above, Krummacher in view of Stokes and Shimizu renders obvious claim 1. As also discussed above with respect to [1a] the photoluminescence material requirement and [1b] the light scattering material requirement of claim 1 above, Krummacher discloses a wavelength conversion layer containing a photoluminescent material and a separate diffusing layer containing a light scattering material.

Krummacher in view of Stokes and Shimizu thus teaches all of the elements of claim 4 and renders claim 4 obvious as a whole. (*See also* EX1102, ¶¶154-56.)

Claim 5: Layers in Direct Contact

Claim 5 requires "[t]he component of claim 4, wherein the wavelength conversion layer and the light diffusing layer are in direct contact with each other."

As discussed above, Krummacher in view of Stokes and Shimizu renders obvious claim 4. 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, "[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. (EX1107, ¶[0038].) Indeed, "[i]n a particularly preferred embodiment, the light scattering translucent layer is applied directly to the luminescence conversion layer." (*Id.*, ¶[0018].)

Krummacher in view of Stokes and Shimizu thus teaches all of the elements of claim 2 and renders claim 2 obvious as a whole. (*See also* EX1102, ¶¶157-60.)

Claim 6: Layers in Light Transmissive Binder

Claim 6 requires “[t]he component of claim 4, 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.”

As discussed above, Krummacher in view of Stokes and Shimizu renders obvious claim 4. Krummacher further discloses the wavelength conversion layer and the light diffusing layer both being mixtures including a light transmissive binder, such as silicone.

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.” (EX1107, ¶[[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.

(EX1107, ¶[[0014].

Silicone is an example of an appropriate synthetic material and is disclosed by Krummacher. (EX1102, ¶¶161-64.) 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.

Although Krummacher does not expressly specify that both layers use the same light transmissive binder, a POSA would have understood Krummacher to disclose that both layers could use the same binder such as silicone, e.g., simply to reduce the number of materials used. (EX1102, ¶165.) Silicone is also pervasive as a binder and encapsulant throughout the state of the art, as shown by the cited references. A POSA would further understand that using a single transmissive binder would result in the layers having similar refractive indexes and thus minimize reflection loss. (*See* EX1107, ¶[[0012] ("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.").) Using a silicone binder is also consistent with avoiding absorption losses. (*See* EX1107, ¶[[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.").)

Moreover, Stokes discloses a light diffusing layer made of silicone: "the radiation scattering particles comprise ceramic or other insulating particles dispersed in the carrier medium selected from glass, such as SiO_2, or a plastic material or a polymer, such as epoxy, silicone or urea resin." (EX1108 at 6:36-40.) Stokes further discloses a wavelength conversion layer 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." (*Id.*, 6:6-9.)

Similarly, 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." (EX1110 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." (*Id.,* at 16:47-49.)

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. (EX1102, ¶¶166-69.) Shimizu, in particular, is cited by both the '539 patent and the prior art. Accordingly, it would have been obvious for a POSA to look to Shimizu and Stokes for details of the conventional white-light LED light source used in Krummacher. Such a POSA would have had a reasonable expectation of success in using the conventional white-light LED light source disclosed in the prior art as directed by Krummacher. Not only does Krummacher suggest the use of an LED with a binder like that disclosed in Stokes and Shimizu, doing so would have been the simple substitution of one known element for another to obtain predictable results. (*Id*.)

Krummacher in view of Stokes and Shimizu thus discloses or suggests all of the elements of claim 6 and renders claim 6 obvious as a whole.

Claim 7: Light Transmissive Binder is Silicone

Claim 7 requires "[t]he component of claim 6, 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."

As discussed above, Krummacher in view of Stokes and Shimizu renders obvious claim 6. As also discussed above with respect to claim 6, 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." (EX1107, ¶[[0037].)

Moreover, Stokes discloses a light diffusing layer made of silicone: "the radiation scattering particles comprise ceramic or other insulating particles dispersed in the carrier medium selected from glass, such as SiO_2, or a plastic material or a polymer, such as epoxy, silicone or urea resin." (EX1108 at 6:36-40.) Stokes further discloses a wavelength conversion layer 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." (*Id.,* at 6:6-9.)

Similarly, 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." (EX1110 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." (*Id.,* at 16:47-49.)

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 '539 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. (EX1102, ¶174.)

Krummacher in view of Stokes and Shimizu thus teaches all of the elements of claim 6 and renders claim 6 obvious as a whole. (*See also* EX1102, ¶¶170-175.)

Claim 8: Weight Loading of Light Scattering Material

Claim 8 depends from claim 6 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%."

Krummacher in view of Stokes and Shimizu discloses or renders obvious this limitation. For example, Stokes discloses that "[p]referably, layer 156 comprises a silicone layer containing a dispersion of 5-10% amorphous silica particles having a mean diameter of 120 to 200 nm…." (EX1108, 8:21-24.) In the case where claimed ranges "overlap or lie inside ranges disclosed by the prior art" a *prima facie* case of obviousness exists. *In re Wertheim,* 541 F.2d 257, 191 USPQ 90 (CCPA 1976).

Krummacher in view of Stokes and Shimizu thus teaches all of the elements of claim 8 and renders claim 8 obvious as a whole. (*See also* EX1102, ¶¶176-78.)

Claim 9: Deposition Methods

Claim 9 depends from claim 4 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."

Krummacher in view of Stokes and Shimizu discloses or renders obvious this limitation. For example, Krummacher teaches that

> 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.

(EX1107, ¶[0014].) Stokes similarly discloses a layer of "preferably about 0.5 micron thick [is] vacuum deposited or spin-on SiO2 layer over the top of the LED chip 53." (EX1108, 7:57-59.)

Krummacher in view of Stokes and Shimizu thus teaches all of the elements of claim 9 and renders claim 9 obvious as a whole. (*See also* EX1102, ¶¶179-81.)

Claim 10: Planar Shapes

Claim 10 requires "[t]he component of claim 4 in which the wavelength conversion layer and the light diffusing layer comprises planar shapes."

As discussed above, Krummacher in view of Stokes and Shimizu renders obvious claim 4. 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.

(EX1107, ¶[[0016].)

Krummacher in view of Stokes and Shimizu thus teaches all of the elements of claim 10 and renders claim 10 obvious as a whole. (*See also* EX1102, ¶¶182-84.)

Claim 11: Dome or Elongated Dome Shaped Light Diffusing Layer

Claim 11 depends from claim 4 and requires that "the light diffusing layer comprises a dome or elongated dome shape."

As discussed above, Krummacher in view of Stokes and Shimizu renders obvious claim 4. Krummacher in view of Stokes and Shimizu also discloses or renders obvious this limitation. In particular, Stokes and Shimizu disclose LED light sources with light diffusing layers and that such devices may have a dome shape. (*See, e.g.*, EX1108, fig. 4 (Stokes duplicating Shimizu).)

Krummacher in view of Stokes and Shimizu thus teaches all of the elements of claim 11 and renders claim 11 obvious as a whole. (*See also* EX1102, ¶¶185-87.)

Independent Claim 18: A Light Emitting Device

Claim 18 requires a "light emitting device comprising" the wavelength conversion component of claim 1 and "at least one solid-state light emitter operable to generate excitation light."

As discussed above, Krummacher in view of Stokes and Shimizu renders obvious claim 1 and also discloses a light emitting device including "at least one solid-state light emitter operable to generate excitation light." 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 EX1107, ¶[[0004] (explaining relevance to lighting based on "organic light-emitting diodes (OLEDs)" and "LEDs or LED modules having one or more radiation-emitting semiconductor chips").

The combination of Krummacher, Stokes, and Shimizu thus discloses or suggests all of the elements of claim 18 and renders claim 18 obvious as a whole. (See also EX1102, ¶¶188-91.)

Claim 19: Applications for the Light Emitting Device

Claim 19 requires "The device of claim 18, wherein the light emitting device is selected from the group consisting of: … traffic lights … and signs." Shimizu discloses a "light emitting diode used in LED display, back light source, traffic signal, trailway signal, illuminating switch, indicator, etc." (EX1110, 1:12-14.)

The combination of Krummacher, Stokes, and Shimizu thus discloses or suggests all of the elements of claim 19 and renders claim 19 obvious as a whole. (See also EX1102, ¶¶192-93.)

Claim 20: Improved Off-State White Appearance

Claim 20 requires "[t]he device of claim 18 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."

Krummacher discloses that in conventional optoelectronic components:

> "[T]he 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.” (EX1107, ¶[0004].)

Krummacher solves this problem, explaining that:

> 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.

(EX1107, ¶[0041].)

Accordingly, Krummacher discloses the light diffusing layer improves an off-state white appearance of the light emitting device. (*See also* EX1102, ¶¶194-97.) The combination of Krummacher, Stokes, and Shimizu thus discloses or suggests all of the elements of claim 20 and renders claim 20 obvious as a whole. (*See also* EX1102, ¶¶198-201.)

Claim 23: Average Particle Size Less Than 150 nm

Claim 23 requires "the device of claim 18, wherein the light scattering material has an average particle size that is less than about 150 nm." That is, claim 23 claims a range of average particle sizes with the lower bound of claim element 18 ("relatively more") and the upper bound of the exemplary range disclosed by the '539 patent (150 nm). The '539 patent discloses no particular significance to any of these ranges. (EX1102, ¶202; *see also* EX1101, 25:57-62.)

As discussed in detail above, Stokes discloses the routine optimization of average particle size to preferentially scatter blue light and discloses a preferred range of about 100 to 200 nm. (*See, e.g.*, EX1108, 7:4-17; EX1102, ¶203.) Stokes discloses ranges of average particle size that encompass and overlap the claimed range of average particle sizes—including the 100 to 150 nm range that is described as advantageous (EX1101, 8:53-54) and essentially the same as the range required by claim element 1e and claim 18—rendering claim 23 obvious. (EX1102, ¶203.) Moreover, a POSA would have recognized selecting an average particle size as a design decision to be made based on a number of factors, including the light scattering properties of the particles, and well within the skill of the art. (*Id.*)

Claim 24: Planar Shapes

Claim 24 requires "the device of claim 18 in which the wavelength conversion layer and the light diffusing layer comprise planar shapes." 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. (*See, e.g.,* EX1107, ¶[0016]; *see also* EX1102, ¶¶205-07.)

Claim 25: Dome or Elongated Dome Shaped Light Diffusing Layer

Claim 25 requires "the device of claim 18 in which the light diffusing layer comprises a dome or elongated dome shape." Krummacher in view of Stokes renders obvious this limitation. In particular, Stokes disclosse LED light sources with light diffusing layers and that such devices may have a dome shape. (*See, e.g.*, EX1108, fig. 4 (Stokes duplicating Shimizu); *see also* EX1102, ¶¶208-10.)

VII. [GROUND 2] Claims 18 and 28 are rendered obvious by Hussell, Krummacher, Stokes, and Van Woudenberg

Hussell discloses every element in the challenged claims except which particle sizes were known to preferentially scatter blue light and the specific wavelength of the blue light emitted by the LED chip. But light diffusing layers that preferentially scatter blue light and LED chips emitting blue light at greater than or equal to 440 nm were well known in the art as evidenced by Krummacher, Stokes, and Van Woudenberg. Thus, Hussell in view of Krummacher, Stokes, and Van Woudenberg renders obvious all of the challenged claims.

Independent Claims 18 and 28: Light Emitting Devices

Hussell discloses every feature required by independent claims 18 and 28 except Hussell does not explicitly disclose (i) light scattering material that has an average particle size that is selected such that the light scattering material will scatter excitation light from the at least one solid-state light emitter relatively more than the light scattering material will scatter light generated by the at least one photoluminescence material, 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." (EX1111, ¶[0052].) These filaments have YAG phosphor located on or near the outer surface of the tube to convert blue light. But such YAG phosphors – the same phosphors disclosed in Krummacher, Stokes, and Shimizu – appear yellow in the off-state. As disclosed in Krummacher (and other references discussed herein), such yellow appearance is undesirable. 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 by Krummacher. (EX1102, ¶211-13.) Stokes further discloses that a light diffusing layer, such as in Krummacher, may preferentially scatter blue light.

(EX1108, fig.6.) And Van Woudenberg discloses the wavelength range of blue LEDs like those in Hussell. (EX1120, 5:14-24; Fig. 2.)

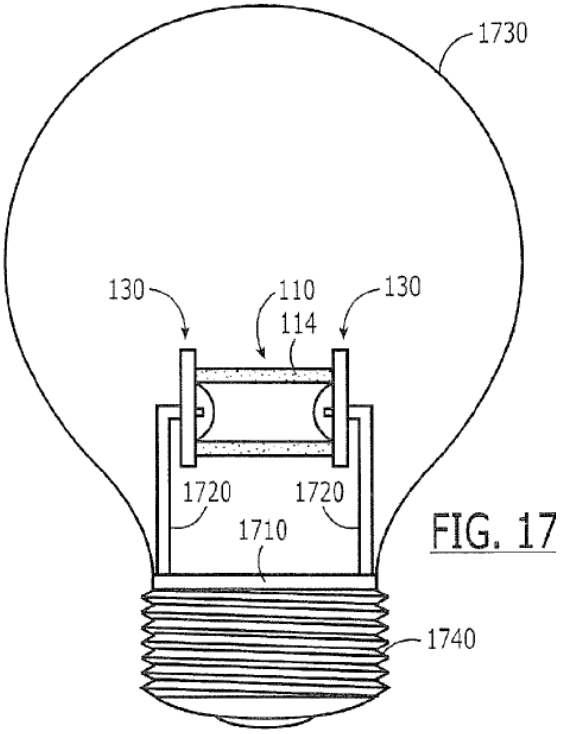
Both claims recite substantially overlapping subject matter. In particular, the wavelength conversion component recited in both claims has identical requirements to the requirements of the wavelength conversion component of claim 1. For ease of discussion, Petitioners address these requirements together.

[pre/a] A light emitting device or light bulb comprising at least one solid-state emitter

Claim 18 covers any light-emitting device, while claim 28 covers a light bulb with a connector base configured to be inserted in a socket. Both require at least one "solid-state light emitter."

Hussell discloses a "semiconductor light emitting apparatus" (EX1111, Abstract) that can be implemented in various configurations such as a light bulb. (*See id*. Fig. 17, ¶[0014], ¶[0052] (Figure 17 includes "bulb 1730").) (*See also* EX1102, ¶216.) 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." (EX1111, ¶[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. (EX1102, ¶216.)

With respect to claim 28, Hussell discloses a light bulb with “a connector base configured to be inserted in a socket to form an electrical connection for the light bulb.” 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. (EX1102, ¶217.) 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.” (EX1111, ¶[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

[b] …wavelength conversion component … defin[ing] a light mixing chamber

Claim 18 requires a wavelength conversion component, and claim 28 further requires the wavelength conversion component to define a light mixing chamber. Hussell discloses the LED devices configured so that claimed wavelength conversion component defines a light mixing chamber.

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." (EX1111, ¶[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. (EX1102, ¶219.)

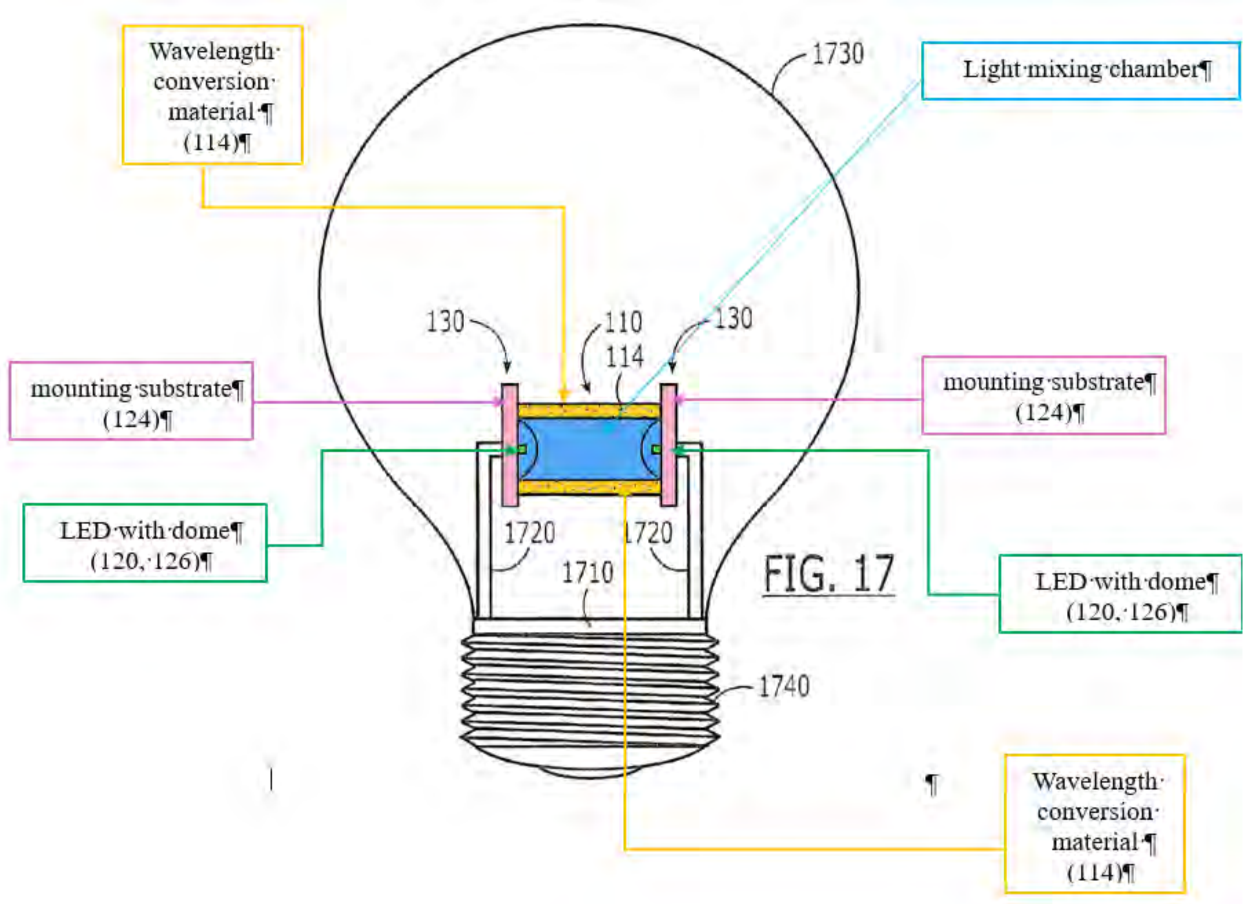
Moreover, as shown in the annotated Figure 17 below, the two LEDs in Hussell are contained within the ends of a three-dimensional wavelength conversion tube 110. (*See also* EX1111, ¶[0052] ("as shown in Fig. 17, an elongated hollow wavelength conversion tube 110 includes a packaged semiconductor device 130 at either end").) (*See also* EX1111, ¶[0032], Fig. 1, EX1102, ¶220.)

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.[5] (*See also* EX1111, ¶[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

---

[5] The '539 patent equates the light mixing chamber of the wavelength conversion component with its interior volume. (EX1101, 24:54-55 ("The interior volume may also be referred to as a light mixing chamber.").)

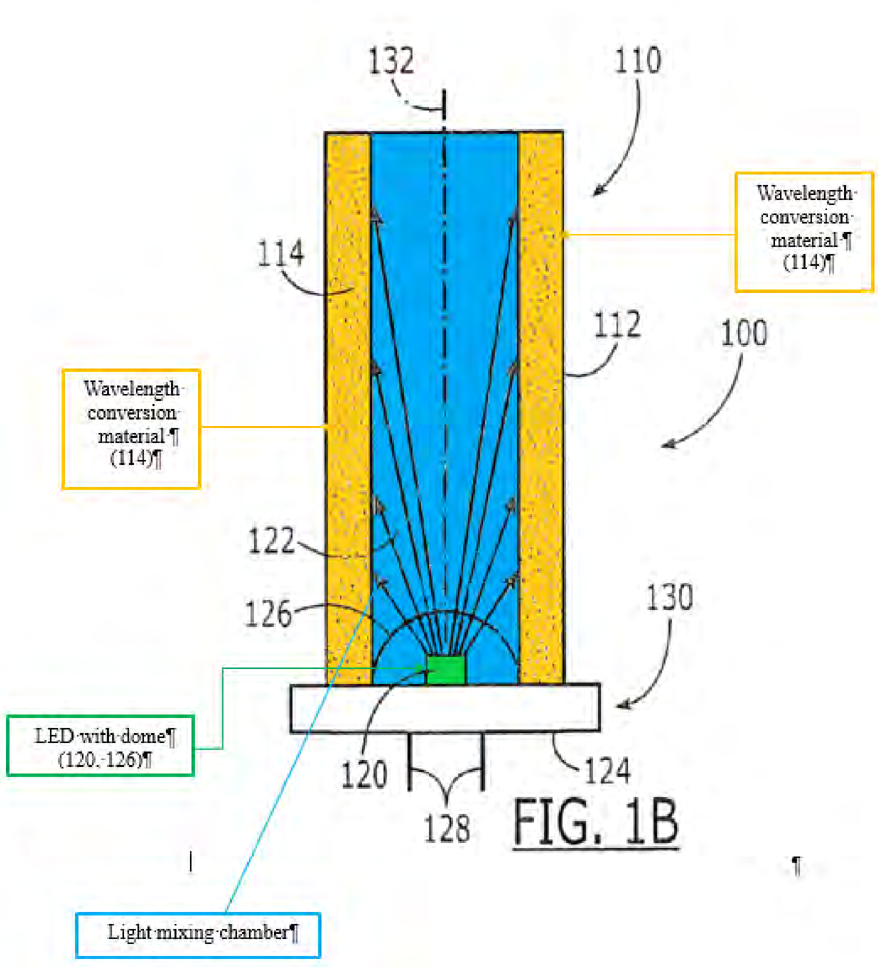
surface of the tube wall 110, as shown by ray 310, and also refracts within the tube wall"); EX1102, ¶221.)



Hussell, Annotated Figure 17

[c] at least one photoluminescence material; and

The combination of Hussell and Krummacher 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." (EX1111, Abstract.) Phosphor is a photoluminescence material because it converts light from one wavelength to another and is excitable by the blue, excitation light. (EX1102, ¶222.) “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.” (EX1111, ¶[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 tube wall constitute the claimed wavelength conversion layer as shown in annotated Figure 1B below.



Hussell, Annotated Figure 1B

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

[d] a light scattering material

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. (EX1102, ¶224.) Hussell discloses cerium-doped yttrium aluminum garnet (YAG)[6] as an exemplary "yellow phosphor" that can be used in the wavelength conversion tube. (EX1111, ¶[0006].) A POSA would understand that the YAG phosphor disclosed in Hussell (*see* EX1111, ¶[0036]) has the same yellowish appearance in the off state as the YAG phosphors in Krummacher. (EX1102, ¶224.) As discussed in detail above, Krummacher discloses a light-scattering layer:

> 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.

(EX1107, ¶41.)

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[6] This is the same YAG phosphor used in Van Woudenberg, Krummacher, and Stokes for the same purpose – creating white light through phosphor conversion with a blue-light LED. (*See, e.g.*, EX1120, 5:19-20.)

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 (EX1120). Specifically, Van Woudenberg discloses the need to create an off-state white appearance in YAG phosphor-coated LEDs (pc-LEDs) used in mobile phone applications and general lighting devices such as luminaires and downlights. (*See* EX1120, 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 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* EX1120, 1:14-28.)

Hussell, like Van Woudenberg, teaches a general illumination device, an LED light bulb. (EX1102, ¶¶225-26.) Accordingly, Van Woudenberg evidences why a POSA would be motivated to change the unattractive off-state yellowish appearance of Hussell's YAG phosphor wavelength conversion tube to a more neutral off-state white appearance. (EX1102, ¶226.)

Like Van Woudenberg, Krummacher discloses using a light scattering layer to improve an off state white appearance. (EX1107, ¶41.) Thus, in view of Van Woudenberg, a POSA would be motivated to use the solution provided by Krummacher in general lighting applications like light bulbs. (EX1102, ¶227.)

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. (EX1102, ¶228.) As discussed above, the light diffusing layer in Krummacher is comprised of light scattering particles (e.g., TiO_2) dispersed in silicone. (*See supra* claims 6, 7.) Krummacher discloses that the light diffusing layer can be "produced by spin coating" or "applied by laminating or gluing." (EX1107, ¶[0031].) A POSA would understand that a layer that is "produced by spin coating" is simply a coating applied to another material. (EX1102, ¶228.) Moreover, because Hussell discloses that the wavelength conversion tube can be constructed from a wide variety of materials including plastic, epoxy or silicone, (EX1111, ¶[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 Krummacher to the outer surface of the wavelength conversion tube in a coating or other method taught by Hussell such as molding or extrusion. (EX1111, ¶[0036]; EX1102, ¶228.)

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." (EX1111, ¶[[0048].) Adding a light scattering structure to the exterior surface of the tube as taught by Krummacher would also enhance light scattering. (*See, e.g.*, EX1107, ¶[0011].) This provides a separate motivation for a POSA to combine the TiO_2-containing layer of Krummacher with Hussell. (EX1102, ¶¶229-30.)

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.

[e] wherein the light scattering material has an average particle size that is selected such that the light scattering material will scatter excitation light from a radiation source relatively more than the light scattering material will

scatter light generated by the at least one photoluminescence material

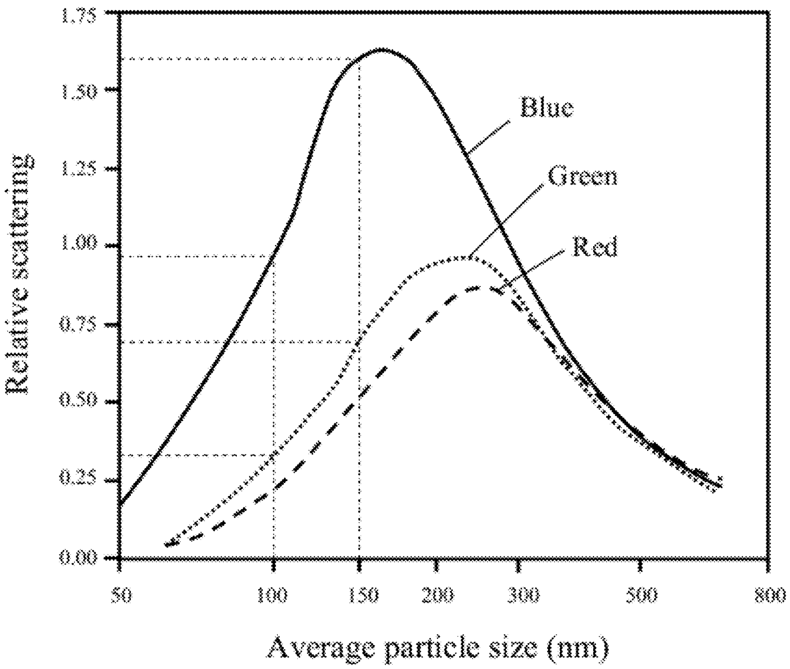
Krummacher in view of Stokes discloses that the light scattering material has an average particle size that is selected such that the light scattering material will scatter excitation light from a radiation source relatively more than the light scattering material will scatter light generated by the at least one photoluminescence material.

Consistent with claim 1[c], Stokes discloses:

> 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.

(EX1108, 7:1-4.)

As discussed in detail above, Figure 10 of the ’539 patent is essentially the same as graphs found in the prior art, including Figure 6 of Stokes, that were derived from the DuPont model described in the background (Section II.C.2.c) above. In particular, the graphs purport to show the relative scattering power of TiO_2 based on particle size for different colors of light. (EX1102, ¶¶231-32.)



’539 Patent, Figure 10

Krummacher discloses a light scattering material with TiO_2 particles “preferably having a radius of between 50 nm inclusive and 1000 nm inclusive.” (EX1107, ¶[0039].) According to the DuPont model, TiO_2 particles of such a size generally scatter more blue light (e.g., excitation light) than red or green light (e.g., light emitted by the phosphor). (EX1102, ¶233.) Accordingly, Krummacher renders obvious this claim element by literally disclosing the selection of average particle sizes that preferentially scatter blue light.

To the extent that the claim language “an average particle size that is selected such that [it preferentially scatters blue light]” requires an average particle size selected for that reason (rather than an average particle size that leads to that outcome), this claim element is rendered obvious by Stokes. (EX1102, ¶234.) Stokes explicitly discloses the selection of an average particle size "such that the particles preferentially scatter blue … LED light as compared to yellow … light from the luminescent material." (EX1108, 7:1-4.)

A POSA would have had reason to use such a basis for selecting average particle size as taught by Stokes. (EX1102, ¶¶235-36.) For example, Stokes discloses:

> [The relevant] 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.

(EX1108, 7:17-26.)

Thus, a POSA would have been motivated to apply this principle to Krummacher, because it would increase the conversion of blue light to yellow light and improve the uniformity of the light source. (EX1102, ¶237.) Conversion of blue light to yellow light is improved by maximizing the scattering of blue light.

(*Id.*) Uniformity is improved by preferentially scattering the concentrated light from the blue-light LED chip instead of the diffuse light emitted by the phosphor. (*Id.*)

A POSA would have had a reasonable expectation of success applying this principle to Krummacher, because the relevant particle size range includes the range disclosed by Krummacher. A POSA would have recognized selecting an average particle size as a design decision to be made based on a number of factors, including the light scattering properties of the particles, and well within the skill of the art. (EX1102, ¶238.)

Accordingly, Krummacher in view of Stokes discloses that the light scattering material has an average particle size that is selected such that the light scattering material will scatter excitation light from a radiation source relatively more than the light scattering material will scatter light generated by the at least one photoluminescence material.

[f] 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.

The combination of Hussell in view of Krummacher, Stokes, and Van Woudenberg 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. (EX1111, ¶[0037].) Hussell further explains, through reference to Figures 3 and 3A, that some of the emitted blue light passes through the tubular wavelength conversion component:

> [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.

(EX1111, ¶[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.").)

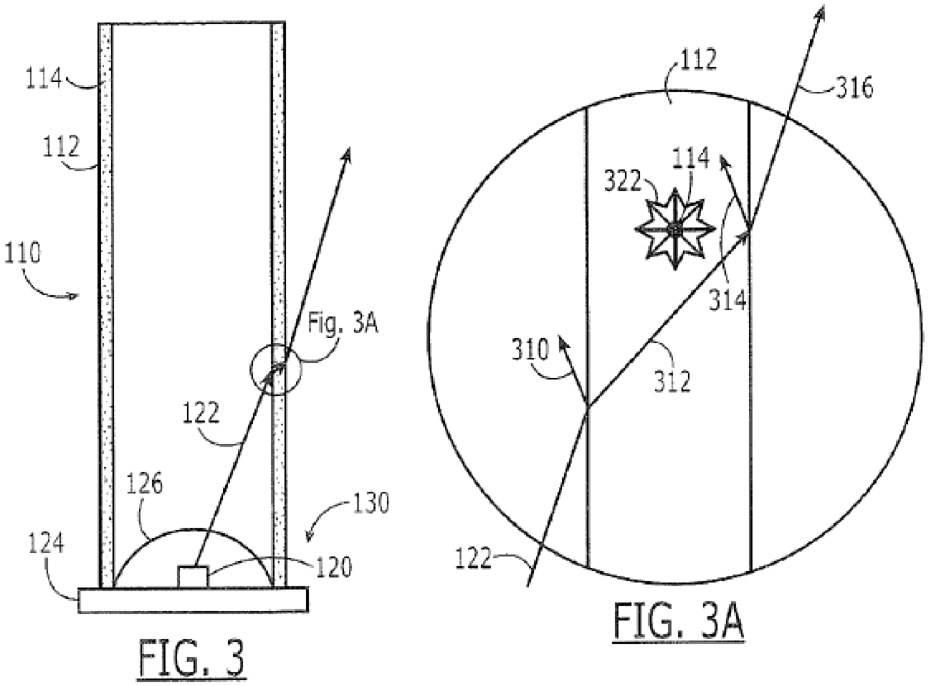


FIG. 3

FIG. 3A

Hussell, Figures 3-3A

A POSA would understand that that the blue light emitted by the semiconductor light emitting device in Hussell in view of Van Woudenberg, further in view of Krummacher has a wavelength of greater than or equal to 440 nm. (EX1102, ¶240-41.) 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. (EX1120, 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.

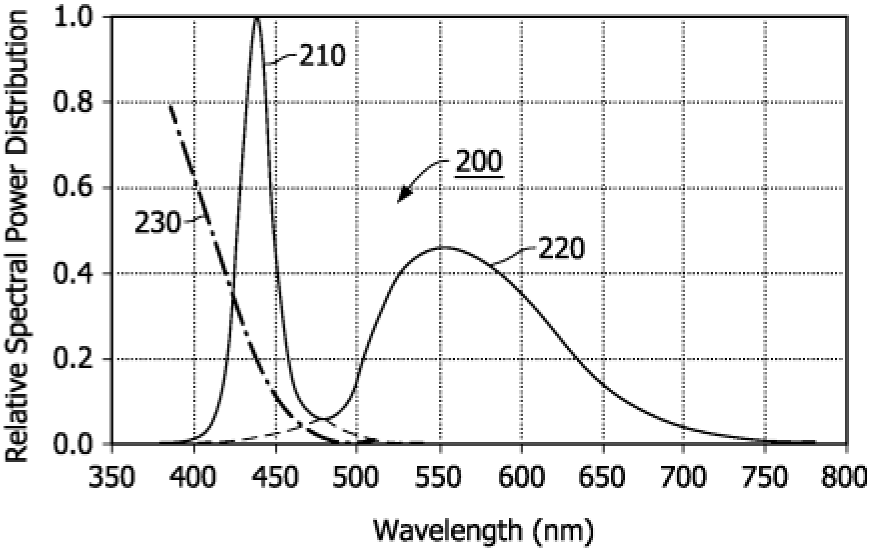


FIG. 2

Van Woudenberg, Figure 2

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. (EX1102, ¶242-43.)

Hussell in view of Krummacher, Stokes, and Van Woudenberg thus discloses this limitation.

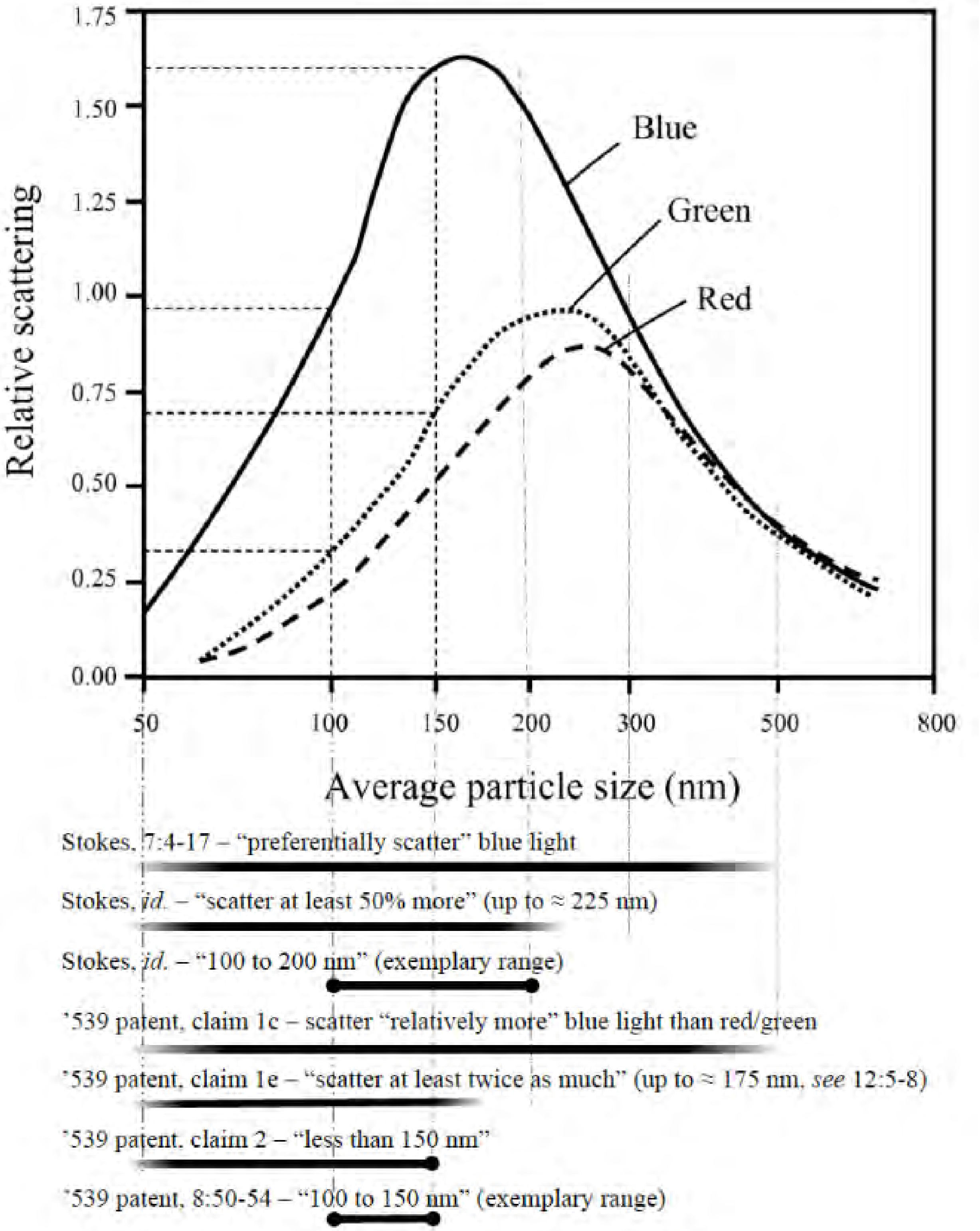
[g] wherein the light scattering material scatters the blue light at least twice as much as light generated by the at least one photoluminescence material

The combination of Hussell and Krummacher in view of Stokes discloses this limitation. As disclosed by Stokes, the light diffusing layer taught by Krummacher scatters blue light at least twice as much as light generated by at least one photoluminescence material.

Krummacher in view of Stokes discloses the light scattering material scatters the blue light at least twice as much as light generated by the at least one photoluminescence material.

As discussed above, Krummacher in view of Stokes renders obvious claim element [e]. Claim element [g] only further requires that the "relatively more" of element [e] be "at least twice as much." The '539 patent discloses no particular significance to "at least twice as much" which represents a straightforward narrowing of the claimed average particle size range from claim element [e] so that it extends only up to around 175 nm, with the '539 patent disclosing a preferred range of 0.10 to 0.15 microns (100 nm to 150 nm). (EX1101, 11:65-12:2; *see also* EX1102, ¶¶244-45.) A *prima facie* case of obviousness typically exists when the ranges of a claimed composition overlap the ranges disclosed in the prior art. *Almirall, LLC v. Amneal Pharms. LLC*, 28 F.4th 265, 273 (Fed. Cir. 2022).

Accordingly, claim element [g] is *prima facie* obvious for the same reasons that claim element [e] is obvious. The annotated Figure 10 shown on the next page compares the ranges claimed in the ’539 patent to the ranges disclosed by Stokes. (EX1102, ¶246.)



Stokes, 7:4-17 – "preferentially scatter" blue light

Stokes, *id.* – "scatter at least 50% more" (up to ≈ 225 nm)

Stokes, *id.* – "100 to 200 nm" (exemplary range)

'539 patent, claim 1c – scatter "relatively more" blue light than red/green

'539 patent, claim 1e – "scatter at least twice as much" (up to ≈ 175 nm, *see* 12:5-8)

'539 patent, claim 2 – "less than 150 nm"

'539 patent, 8:50-54 – "100 to 150 nm" (exemplary range)

Annotated Figure 10

Moreover, consistent with claim element [g], Stokes discloses the routine optimization of average particle size to preferentially scatter blue light. (EX1102, ¶¶247-48.) In particular, as reflected in the annotated Figure 10 of the ’539 patent above, Stokes explicitly discloses selecting an average particle size that scatters excitation light at least 1.5 times as much as light emitted by the phosphor and gives an exemplary range of 0.10 to 0.20 microns (100 to 200nm). That is:

> 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).

(EX1108, 7:4-17; *see also* EX1124 (Toquin) at ¶¶[0080]-[0081] (disclosing preferentially scattering blue light using particles of approximately 150 nm).)

In other words, Krummacher discloses the use of particles with “at least a 50% greater scattering power for blue radiation,” which includes the particles that that “scatter[] the blue light at least twice as much.” (*See* EX1102, ¶249.) Thus, as illustrated in the annotated Figure 10 above, the range of average particle size disclosed by Stokes based on preferentially scattering blue light overlaps and entirely encompasses the similar range required by this claim term, rendering it obvious. (*Id.*)

Neither Stokes nor the ’539 patent assign any particular significance to the disclosed ranges, other than that they are based on preferentially scattering blue light. (EX1102, ¶250.) The values recited for the endpoints of both ranges appear to be based on rough estimations in reading DuPont’s chart. (*Id.*) And the difference between the disclosed ranges is one of degree rather than kind. (*Id.*) As discussed above, a POSA would have recognized selecting an average particle size as a design decision to be made based on a number of factors, including the light scattering properties of the particles, and well within the skill of the art. For example, a POSA would weigh the benefits of maximizing the ratio of blue light scattered compared to yellow light with the potential downsides, including not maximizing blue light scattered, decreasing light output due to increased internal reflection, and limiting the commercially-practical options for rutile TiO2 by requiring a narrower range of average particle size. (EX1102, ¶251.)

Accordingly, Krummacher in view of Stokes discloses all elements of this limitation. Thus, Hussell as modified to add the light diffusing layer as taught in Krummacher to the outer surface of the wavelength conversion tube, discloses a light diffusing layer that scatters blue light at least twice as much as light generated by at least one photoluminescence material.

Accordingly, Hussell in view of Krummacher, Stokes, and Van Woudenberg renders obvious independent claims 18 and 28.

VIII. MATERIAL DIFFERENCES FROM PROSECUTION SUPPORT INSTITUTION (35 U.S.C. § 325(d))

None of Krummacher, Stokes, or Hussell were before the Examiner during prosecution and are not similar to any art considered during prosecution. Indeed, the Examiner was not made aware of any of the numerous prior art references disclosing the use of a light diffusing layer with a white-light LED light source despite one such reference being discussed in the Background of the ’539 patent.

The applicants did not inform the Examiner that Shimizu disclosed using a molding containing TiO_2 to obscure the yellow phosphor.

Nor did the applicants inform the Examiner that at least Figure 10 of the ’539 patent was based on information obtained from DuPont and well-known in the prior art.

Each of these disclosures refute the notion that it would not have been obvious to use a light diffusing layer with a white-light LED light source, which was the reason for allowance identified by the Examiner.

Because there are material differences between the art presented here and that applied during prosecution, and because challenged claims issued based on this deficiency of the original examination, discretionary denial is unwarranted based on the same or similar art being applied in this petition.

IX. NO EVIDENCE OF NONOBVIOUSNESS

Petitioners are unaware of any objective indicia, and in any event, the strength of the grounds herein would render such evidence deficient.

X. CONCLUSION

For all the reasons dicussed above, claims 1-11, 18-20, 23-25, and 28 of the ’539 patent are unpatentable. Petitioners request that *inter partes* review be instituted and the claims canceled.

Date: March 6, 2025

Respectfully submitted,

/s/ David C. Radulescu
David C. Radulescu, Lead Counsel
Reg. No. 36,250

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

A. Real Parties-in-Interest (§ 42.8(b)(1))

- In addition to Petitioners Savant Technologies LLC d/b/a GE Lighting, Elong International USA Inc., and Xiamen Longstar Lighting Co. Ltd.; Seoul Semiconductor Co. Ltd. is a Real Party-in-Interest.
- LEDVANCE LLC is not a Real Party-in-Interest, but it does have a business relationship with Seoul Semiconductor Co. Ltd. and is identified here for Board assessment of internal conflicts of interest.

B. Related Matters (§ 42.8(b)(2))

Patent Owner has asserted the ’539 patent in the following action:

- *Feit Electric Co., Inc. v. Savant Technologies LLC d/b/a GE Lighting*, No. 1:24-cv-473 (N.D. Ohio filed Mar. 13, 2024).

The related ’678 patent has been challenged in the following proceedings:

- *Savant Techs. LLC d/b/a GE Lighting, et al. v. Feit Elec. Co, Inc.*, IPR2024-01357 (PTAB filed Aug. 26, 2024, instituted Mar. 5, 2025).
- *Elong International USA Inc., et al. v. Feit Electric Co. Inc*, IPR2025-00258 (PTAB filed Dec. 9, 2024)

- *Savant Techs. LLC d/b/a GE Lighting, et al. v. Feit Elec. Co, Inc.*, IPR2025-00260 (PTAB filed Dec. 9, 2024)

C. Lead and Back-Up Counsel (§ 42.8(b)(3))

Lead Counsel:	Back-Up Counsel:
David C. Radulescu, Ph.D. (Reg. No. 36,250) david@radip.com Savant_IPR_Service@radip.com RADULESCU LLP 5 Penn Plaza, 19th Floor New York, NY 10001 (646) 502-5950 (phone) (646) 502-5959 (facsimile)	Etai Lahav (Provisionally-recognized PTAB attorney) etai@radip.com RADULESCU LLP 5 Penn Plaza, 19th Floor New York, NY 10001 (646) 502-5950 (phone) (646) 502-5959 (facsimile)
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D. Service Information (§ 42.8(b)(4))

Petitioners consent to service by electronic mail at the email addresses in Section C above.

Date: March 6, 2025

Respectfully submitted,

/s/ David C. Radulescu
David C. Radulescu, Lead Counsel
Reg. No. 36,250

CERTIFICATE OF COMPLIANCE (§ 42.24(d))

Pursuant to 37 C.F.R. § 42.24(d), I hereby certify that this petition complies with the type-volume limitation of 37 C.F.R. § 42.24(a). The word count application of the word processing program used to prepare this petition indicates that the petition contains 13,729 words, excluding the parts of the brief exempted by 37 C.F.R. § 42.24(a).

Date: March 6, 2025

/s/ David C. Radulescu
David C. Radulescu, Lead Counsel
Reg. No. 36,250

PAYMENT OF FEES (37 C.F.R. §§ 42.15(A) AND 42.103)

The required fees are submitted herewith. If any additional fees are due at any time during this proceeding, the Office is authorized to charge such fees to Deposit Account No. DA606603.

EXHIBIT LIST

Exhibit No.	Description
EX1101	U.S. Patent No. 8,614,539
EX1102	Declaration of William A. Doolittle, Ph.D. re the ’539 patent
EX1103	Curriculum Vitae of William A. Doolittle, Ph.D.
EX1104	File History for U.S. Pat. Appl. No. 13/273,215 (excl. references)
EX1105	U.S. Pat. Pub. No. 2009/0057699 (“Basin-2007”)
EX1106	U.S. Pat. Pub. No. 2007/0045761 (“Basin-2005”)
EX1107	U.S. Pat. Pub. No. 2008/0079015 (“Krummacher”)
EX1108	U.S. Patent No. 6,791,259 (“Stokes”)
EX1109	U.S. Patent No. 5,998,925 (“Shimizu-APA”)
EX1110	U.S. Patent No. 6,069,440 (“Shimizu”)
EX1111	U.S. Pat. Pub. No. US2010/0124243 (“Hussell”)
EX1112	DuPont: Polymers, Light and the Science of TiO_2 (2007)
EX1113	DuPont: Titanium Dioxide for Coatings (2007)
EX1114	Erik S. Thiele and Roger H. French, “Computation of Light Scattering by Anisotropic Spheres of Rutile Titania”, Adv. Mater. 1998, 10, No. 15
EX1115	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)
EX1116	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)
EX1117	William D. Ross, “Theoretical Light-Scattering Power of Ti02 and Microvoids”, Ind. Eng. Chem., Prod. Res. Develop., Vol. 13, No. 1, 1974
EX1118	[Intentionally omitted]
EX1119	U.S. Patent No. 8,547,010 (“Jagt”)
EX1120	Int’l Pat. Pub. No. WO 2008/044171 A2 (“Van Woudenberg”)
EX1121	Declaration of Etai Lahav
EX1122	[Intentionally omitted]
EX1123	Sudhakar Madhusoodhanan and Devdatt S. Nagvekar, “UV Curable High Opacity Ink Jettable White Ink”, RadTech e|5 2006 Technical Proceedings (2006)

EX1124	U.S. Pat. Pub. No. 2011/0001151 (“Toquin”)
EX1125 to EX1133	[Intentionally omitted]
EX1134	*Feit v. LEDVANCE*, Plaintiff’s Preliminary Claim Constructions, No. 5:24-cv-31 (E.D. Ky.), served Nov. 6, 2024
EX1135	*Feit v. Savant*, Plaintiff’s Final Claim Constructions, No. 1:24-cv-473 (N.D. Ohio), served Dec. 10, 2024
EX1136	*Feit v. Elong*, Joint Claim Construction and Prehearing Statement, No. 3:24-cv-1089 (N.D. Tex.), Dkt. 45
EX1137	Feit v. LEDVANCE, Plaintiff’s Disclosure of Initial Infringement Contentions, No. 5:24-cv-31 (E.d. Ky.), served Aug. 30, 2024
EX1138	Feit v. Savant, Supplemental Initial Infringement Contentions, No. 1:24-cv-473 (N.D. Ohio), served Oct. 8, 2024
EX1139	*Feit v. Elong*, Plaintiff’s Disclosure of Asserted Claims and Preliminary Infringement Contentions, No. 3:24-cv-1089 (N.D. Tex.), served Oct. 23, 2024

CERTIFICATE OF SERVICE

Pursuant to 37 C.F.R. §§ 42.6(e) and 42.105(a), I certify that I caused to be served a true and correct copy of the foregoing petition for *inter partes* review (and accompanying exhibits) by overnight courier (U.S. Postal Service, Federal Express, or UPS), on this date, on Patent Owner at the correspondence address of Patent Owner as follows:

Christopher P. Lightner
Alston & Bird LLP
Vantage South End
1120 South Tryon Street, Suite 300
Charlotte, NC 28203-6818

A courtesy copy was also sent to counsel for Patent Owner in IPR2024-01357 at the following email addresses:

Michael Pomeroy	mpomeroy@carterarnett.com
Alexis Ritzer	aritzer@carterarnett.com
Scott Breedlove	sbreedlove@carterarnett.com

Date: March 6, 2025

/s/ David C. Radulescu
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