UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

AMBILIGHT INC
Petitioner,

v.

LANNRAY OPTOELECTRONICS (ZHENJIANG) CO. LTD
Patent Owner.

Case PGR2026-00053
U.S. Patent No. 12,502,870

DECLARATION OF COLIN A. WOLDEN, PH.D. IN SUPPORT OF PETITION FOR POST GRANT REVIEW OF U.S. PATENT NO. 12,502,870

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I, Colin Wolden, hereby declare as follows:

I. INTRODUCTION

1. I am over the age of 18 and am competent to submit this declaration. The statements and opinions herein are based on my personal knowledge and upon my background, education, research, training, and experience relating to the subject matter discussed.

2. I have been retained by Dickinson Wright PLLC on behalf Petitioner Ambilight Inc ("Ambilight" or "Petitioner") in this matter to offer technical opinions relating to U.S. Patent No. 12,502,870 ("the '870 Patent") and to submit this declaration in connection with the Post Grant Review ("PGR") of Claims 1-12 of the '870 Patent. If called upon to do so, I am prepared to testify as an expert witness in this regard.

II. BACKGROUND AND QUALIFICATIONS

3. I received a B.S. in Chemical Engineering from the University of Minnesota in 1990, an M.S. in Chemical Engineering Practice from the Massachusetts Institute of Technology ("MIT") in 1992, and a Ph.D. in Chemical Engineering from MIT in 1995.

4. From 1995-1997, I was a National Research Council/Army Research Office Postdoctoral Fellow and conducted my research at North Carolina State University, Department of Materials Science.

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5. From 1997-2002, I was an assistant professor in the Department of Chemical Engineering at the Colorado School of Mines in Golden, Colorado. In 2002, I was promoted to Associate Professor with Tenure, and in 2008, I was promoted to Full Professor.

6. In 2010, I was appointed the Weaver Distinguished Professor in the Department of Chemical and Biological Engineering at the Colorado School of Mines. Since August 2024, I have served as the William K. Coors Distinguished Chair and Professor in the same Department of Chemical and Biological Engineering at the Colorado School of Mines. I have also held a joint appointment with the National Laboratory of the Rockies (formerly NREL) since 2017. Since 2022, I have also served as Co-founder and Chief Scientific Officer of Blaze Energy Technologies.

7. My areas of expertise and research interests include the development of thin film deposition techniques for the molecular engineering of nanostructured thin film structures, with specific applications in renewable energy, solid state ionics, membranes, and microelectronics. My current research interests more specifically include (1) catalytic membrane reformers; (2) nanostructured membranes; (3) chalcogenide-based photovoltaics and solid state battery materials; (4) fusion fuel processing; (5) macroscopic modeling of plasma and thermal CVD reactors; and (6)

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understanding the fundamental process-structure-property-performance relationships in these systems.

8. I have authored or co-authored over 150 peer-reviewed academic publications in the field of chemical engineering, including thin film deposition and electrochromic films. My publications include work specifically directed to electrochromic tungsten oxide films, electrochromic performance, nanocomposite electrochromics, and smart windows. I have also delivered invited presentations relating to electrochromic films, smart windows, and related thin film technologies.

9. In addition, I have been an associate editor for the Journal of Vacuum Science and Technology (2010-2020) and a reviewer for numerous chemical engineering journals, including *Applied Physics Letters, Journal of Materials Science, Materials Letters, Journal of the Electrochemical Society, Chemical Engineering Education, Vacuum, Diamond and Related Materials, Thin Solid Films, Journal of Electronic Materials, Langmuir, Journal of Crystal Growth, Macromolecules, Surface and Coatings Technology, Optical Materials, Solar Energy Materials and Solar Cells, Applied Surface Science, Plasma Chemistry and Plasma Processing,* and *Journal of Materials Chemistry*.

10. For my contributions to thin film deposition technology, I was elected a Fellow of the American Vacuum Society (AVS) in 2014, a recognition given to AVS members who have made sustained and outstanding technical contributions in

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areas of interest to the AVS. The membership percentage of Fellows cannot exceed 0.5% of AVS members in any calendar year.

11. I have extensive experience in the deposition of thin films, including the deposition of transparent conducting oxides, such as indium tin oxide (ITO). I also have extensive experience in electrochromics, both in my laboratory at the Colorado School of Mines and through collaborative work with the National Renewable Energy Laboratory (NREL) in Golden, Colorado. I have expertise in several thin film deposition techniques including sputtering, evaporation, plasma-enhanced chemical vapor deposition, chemical bath deposition, and ultrasonic spray deposition. Further, I have extensive experience on the interpretation and use of thin film characterization techniques such as X-ray diffraction (XRD), selected area diffraction (SAD), and transmission electron microscopy (TEM) for the determination of crystal size and structure. I also have extensive expertise in opto-electronic characterization of both thin films and complete devices using techniques such as four point probe, UV-Vis-NIR spectrophotometry, current-voltage, capacitance-voltage, cyclic voltammetry, and electrochemical impedance spectroscopy.

12. I am a named inventor on multiple United States patents and patent applications. These include, among others, patent filings relating to electrochromic

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tungsten oxide for optical modulation, as well as additional patents and applications in thin films, photovoltaics, membranes, and related materials technologies.

13. In recognition of my technical contributions, I was awarded the E. T. S. Walton Fellowship by Science Foundation Ireland in 2010. I have also received numerous professional honors and awards during my career, including an NSF CAREER Award and other distinctions listed in my curriculum vitae.

14. A copy of my latest curriculum vitae (CV) is attached as **Appendix A**.

15. I have been retained as an expert in other *Inter Partes* Review ("IPR") matters regarding electrochromic systems. This includes, for example, IPR2015-00245 involving U.S. Patent No. 7,193,763 titled "Electrochemical/electrocon trollable device electrode." This also includes IPR2026-00367 involving U.S. Patent No. 10,539,851 titled "Method for changing states of electrochromic film."

16. In addition to my general knowledge from education and experience in this field, I have reviewed and considered, among other things: the '870 Patent, the prosecution history of the '870 Patent, the prior art of record, and the prior art described in this Declaration. I have also researched and reviewed other prior art references that are relevant to the '870 Patent.

III. SCOPE OF ASSIGNMENT AND MATERIALS REVIEWED

17. I have been retained as an expert on behalf of Ambilight to provide information and opinions to the Patent Trial and Appeal Board ("the Board") to

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assist in its analysis of the patentability of the '870 Patent in the above-captioned Post Grant Review.

18. I am being compensated at the rate of $300 an hour. My compensation does not depend on the substance of my opinions nor on the outcome of this proceeding.

19. In formulating my opinions herein, I have relied upon my training, knowledge, and experience that are relevant to the '870 Patent. Furthermore, I have specifically considered the following documents listed below in addition to any other documents cited in this declaration. I understand that the references are true and accurate copies of what they appear to be:

Exhibit No.	**Description**
EX1001	U.S. Patent No. 12,502,870 ("the '870 Patent")
EX1002	File History of the '870 Patent
EX1003	Declaration of Dr. Colin Wolden
EX1004	Gauthier (U.S. Patent No. 9,810,963)
EX1005	Xu (U.S. Patent No. 7,826,124)
EX1006	Tonar (U.S. Patent No. 6,700,692)
EX1007	Carl M. Lampert, "Durability of Electrochromic Switching Devices for Glazings," Lawrence Berkeley Laboratory Report No. LBL-24103 Rev., presented at The International Congress on Optical Science and Engineering, The Hague, The Netherlands, Mar. 12-15, 1990, and published in *Optical Materials Technology for Energy Efficiency and Solar Energy Conversion IX*, Proc. SPIE Vol. 1272, 1990.
EX1008	Hulya Demiryont & Kenneth Shannon III, "Solid-State Monolithic Electrochromic Switchable Visors and Spectacles," in *Head- and Helmet-Mounted Displays XIV: Design and Applications*, Proc. of SPIE Vol. 7326, 73260K, 2009.

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EX1009	R. Vergaz, J.M. Sánchez-Pena & D. Barrios, "Microcontrolled Electrooptic System for Online Light Transmission Control of Novel Electrochromic Devices," *Microwave and Optical Technology Letters*, Vol. 48, No. 8, pp. 1572-1574, Aug. 2006.
EX1010	Gunnar A. Niklasson & Claes G. Granqvist, "Electrochromics for Smart Windows: Thin Films of Tungsten Oxide and Nickel Oxide, and Devices Based on These," *Journal of Materials Chemistry,* Vol. 17, pp. 127-156, 2007.
EX1011	C.G. Granqvist, E. Avendaño & A. Azens, "Novel Electrochromic Materials and Devices," *46th Annual Technical Conference Proceedings*, Society of Vacuum Coaters, p. 75 et seq., 2003, ISSN 0737-5921.
EX1012	U.S. Patent No. 5,610,756
EX1013	U.S. Patent No. 4,519,930
EX1014	WO 03/011688
EX1015	U.S. Patent No. 4,712,879
EX1016	[intentionally left blank]
EX1017	U.S. Patent No. 5,233,461
EX1018	U.S. Patent No. 6,195,193

IV. LEGAL STANDARDS AND UNDERSTANDINGS APPLIED

20. I am not an attorney. In connection with the opinions that I am offering herein, I am relying upon the legal standards and understandings that Petitioner's attorneys have provided and/or explained to me, which I summarize below.

21. I understand that in an PGR proceeding, the Petitioner has the burden to prove that the challenged claims are unpatentable by a preponderance of the evidence. I understand that a "preponderance of the evidence" means that a fact is more likely than not to be true.

22. I understand that the first step in analyzing the patentability of a claim over the prior art is to determine the claim's meaning and scope from the perspective

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of a person having ordinary skill in the art ("POSA"), *i.e.* what I understand is called claim construction. Next, I understand that the claim as construed is compared to the prior art, as described in more detail below.

23. I understand that each claim must be analyzed from the perspective of a POSA at the time of invention. Petitioner's counsel has asked me to consider the state of the art from the perspective of a POSA during the time period shortly before November 14, 2018, which is the earliest claimed priority date listed on the face of the '870 Patent.

24. I understand that several factors should be considered in determining the ordinary level of skill in the art including (1) the types of problems encountered in the art; (2) the prior art solutions to those problems; (3) the rapidity with which innovations are made; (4) the sophistication of the technology; and (5) the educational level of active workers in the field of the patent.

25. I have been informed by Petitioner's counsel that in this proceeding, the Board interprets the claims of a patent in an PGR under the same standards used in a United States District Court. I understand that this standard requires interpreting the claims through the lens of a POSA in view of the entire patent and the prosecution history. I understand that, unless an express claim construction is adopted by the Board for any term, the terms of the claims should be given their plain and ordinary meaning to a POSA at the time of the invention, in the light of

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the specification and prosecution history. Accordingly, in formulating my opinions, I have reviewed the claims of the '870 Patent as I perceive a POSA would have understood them at the time of the earliest claimed priority date (November 14, 2018) of the '870 Patent, after reading the entire '870 Patent specification and the prosecution history.

26. I understand that, for a patent to be "anticipated" by the prior art, every limitation of the claim must be found expressly, implicitly or inherently, to be disclosed and arranged as required by the claim, in a single prior art reference which describes the claimed invention in sufficient detail to enable a person of ordinary skill in the art to carry out the claimed invention. I understand that if one limitation of a claim is missing from that prior art, then the claim is not anticipated by the prior art.

27. I understand that a limitation of a claim may be expressly disclosed in the prior art even if the prior art does not use identical terminology. Rather, I understand that the focus is whether the substance of the limitation is disclosed. I understand that a limitation that is not expressly disclosed may be considered to be implicitly disclosed based on the inferences that a POSA would be expected to draw from the express disclosures based on the POSA's knowledge and experience. Moreover, I understand that where an item is not expressly or implicitly disclosed in an item of prior art, the prior art may be considered to disclose that limitation

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inherently if the limitation would be necessarily present in the prior art, such as when a characteristic necessarily flows from the teachings of the applied prior art.

28. I understand that even if a claimed invention is not anticipated, the claimed invention is still unpatentable as obvious if the differences between the claimed invention and the prior art are such that the claimed invention as a whole would have been obvious before the effective filing date of the claimed invention to a POSA.

29. I understand that there must have existed an apparent reason, as of the effective filing date, for a POSA to have combined the prior art references in the manner claimed. I understand that reasons that can support conclusion of obviousness include:

- Combining prior art elements according to known methods to yield predictable results;
- Simple substitution of one known element for another to obtain predictable results;
- Use of known technique to improve similar devices (methods, or products) in the same way;
- Applying a known technique to a known device (method, or product) ready for improvement to yield predictable results;
- "Obvious to try" – choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success;
- Known work in one field of endeavor may prompt variations of it for use in either the same field or a different one based on design incentives or other market forces if the variations are predictable to one of ordinary skill in the art;

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- Some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention.

V. LEVEL OF ORDINARY SKILL IN THE ART

30. Based on my experience, and applying my above-explained understanding of the relevant legal principles, it is my opinion that a POSA of the '870 Patent, at the time of its claimed earliest filing date, would have had at least a bachelor's degree in electrical engineering, materials science, chemical engineering, physics, or a similar discipline, and at least 2-3 years of experience working with electrochromic devices, thin-film optical devices, smart-window systems, electrochemical devices, or control systems for such devices. Additional education, such as a master's degree or Ph.D. in one of these fields, could substitute for some practical experience.

VI. CLAIM CONSTRUCTION

31. Based on my experience, and applying my above-explained understanding of the relevant legal principles, it is my opinion that no express construction of any claim term of the '870 Patent is needed to resolve any of the issues of patentability I opine about here. Except as otherwise noted below, I have applied the plain and ordinary meaning of the terms of the patent to a POSA as of the purported earliest filing date in light of the specification and the prosecution history.

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32. I understand that claim construction is ultimately a question of law, and that the Board may choose to provide a construction of certain terms should any dispute arise between the parties over how a term should be construed. I reserve the right to review and potentially modify any of my opinions discussed below in view of any such claim construction which is adopted by the Board or any other tribunal.

VII. BACKGROUND OF THE TECHNOLOGY

33. Electrochromic technology was already a well-developed field well before the earliest effective filing date of the '870 Patent. Electrochromic devices were understood as devices that could reversibly change visible appearance and optical performance in response to an applied electrical input, as reflected in changes in transmittance, reflectance, absorptance, or optical density. (EX1010, 127-128; EX1011, 75-76.) In practical terms, these devices were already being used or proposed for products such as smart windows, rear-view mirrors, display devices, visors, spectacles, goggles, and aircraft transparencies. (EX1008, Abstract; EX1008, 73260K-1; EX1010, 127-128; EX1011, 75-76; EX1012, Abstract; EX1014, Abstract.) For example, EX1008 describes solid-state monolithic electrochromic switchable visors and spectacles for use in helmets and eyewear, while EX1009 describes a microcontrolled electro-optic system for online light-transmission control of electrochromic devices. (EX1008, Abstract, 73260K-1; EX1009, 1572-1573.) By the time of the alleged invention, a person of ordinary skill in the art would

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have viewed electrochromic devices as a familiar class of electrically driven light-control systems. (EX1004, 1:10-21; EX1010, 127-128.)

34. Electrochromic devices generally used a layered architecture by the time of the alleged invention. At a high level, a typical device included outer support layers (or conventionally called substrates), electrode layers, and a multilayer stack (or switching material layers) positioned between the electrodes. The substrates, at least one of which is transparent to allow light to pass into or through the device, can provide mechanical support. These transparent substrates have been commonly made of glass or polymer substrates, though opaque substrates (e.g., metal, ceramic, or reflective materials) could be used when transparency was not required on both sides. The electrode layers provided the electrical pathway for applying voltage or current across the active electrochromic stack. In devices requiring optical transparency, these electrode layers (also called transparent conductive layers), were commonly formed from transparent conductive coatings such as indium tin oxide (ITO), fluorine-doped tin oxide (FTO), other transparent conductive oxides, thin metals or metal oxides, or transparent conductive polymers. (EX1004, 23:13-30; EX1005, 5:41-6:42.) For the purpose of this description, the terms "electrode layer", "transparent conductive layer" and "transparent conductive coating" refer to the same physical structure when transparency is required. In many electrochromic devices, a transparent conductive coating is applied directly to a supporting

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substrate. Although the coated substrate is sometimes referred to simply as a "substrate" in the literature, it functionally provides both mechanical support (via the substrate) and electrical conduction (via the coating). The prior art therefore recognized that substrates, electrode layers, and active electrochromic materials were conventional components of electrochromic devices.

35. The multilayer stack (or switching material layers) between the electrodes was also well understood. A typical multilayer stack included an electrochromic layer that changed optical state, an ion-conducting electrolyte layer that enabled ion or charge transport, and a charge-storage or counter-electrode layer that balanced charge during coloration and bleaching. The prior art teaches electrochromic layers that undergo a reversible redox reaction upon application of an appropriate electrical potential. One redox state corresponds to a colored optical state, while the other corresponds to a bleached (or less colored) state. This electrochromic layer is paired with an optically passive counter-electrode that does not itself change color. In some devices — known as complementary systems — the counter-electrode layer is itself electrochromic. In such systems, the two electrochromic materials form a redox pair, such that one is oxidized while the other is simultaneously reduced when electricity is applied. (EX1004, 20:14-29.) The prior art also teaches that ion-conducting electrolytes, as part of the switching materials, provide the mobile charge carriers (ions) necessary for reversible electrochromic

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switching. (EX1004, 20:43-21:5.) Other known structures, such as busbars, electrical connectors, adhesives, interlayers, and laminating materials were used to deliver electrical power, integrate the electrochromic stack into a finished product, and support laminated glazing constructions. (EX1004, 10:54-11:5, 16:25-41.) A person of ordinary skill in the art therefore would have understood electrochromic devices as layered assemblies in which substrates, electrodes, electrochromic materials, electrolytes, charge-storage materials, electrical connectors, seals, and laminating layers each performed known roles.

36. The Background of the '870 patent confirms the same general understanding. It explains that electrochromism generally refers to a reversible change in optical properties of a material upon application of a potential, and that electrochromic materials exhibit reversible color change due to an electrochemical reduction-oxidation reaction caused by an applied electric field. (EX1001, 1:24-31.) The Background further states that electrochromic materials were useful in a variety of applications, including photovoltaic devices, field effect transistors, organic light emitting diodes, printed electronics, anti-glare windows, and display systems. (EX1001, 1:32-36.) It also acknowledges that electrochromic materials were usually sandwiched between rigid substrates to make devices, and that electrochromic films based on flexible substrates had known advantages over traditional electrochromic

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glass, including reduced weight, ease of transportation, and ability to be applied on curved surfaces. (EX1001, 1:36-41.)

37. The development of electrochromic device control technology has spanned decades. By the early 1980s, electrochromic display devices using electrodes and electrolytes were already known and were operated by applying voltage to produce coloration and bleaching. (EX1013, Abstract.) By the late 1980s and 1990s, electrochromic mirrors had been developed in layered solid-state form, with variable darkening and lightening controlled through electrical input, and with drive circuitry used to establish a desired reflectance level. (EX1015, claim 1; EX1012, Abstract; EX1012, claims 1, 15, 18, 20.) By the early 2000s, electrochromic technology had expanded beyond displays and mirrors to architectural windows, automotive windows, visors, and aircraft transparency windows with variable luminous transmittance. (EX1008, Abstract; EX1011, 75-76; EX1014, Abstract.) Around that same period, the literature also described controller-based electrochromic systems for continuously adjusting light transmission in real time, further reflecting that electrochromic technology had matured into a practical electronic control technology. (EX1009, 1572-1573.)

38. The basic architecture and operation of electrochromic devices were also understood well before 2018. Typical devices included transparent conductive layers, an electrochromic layer, an ion-conducting layer or electrolyte, and often a

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complementary counter or ion-storage layer on glass or flexible polymer substrates. (EX1011, 75-76; EX1010, 127-128.) Applying voltage across those conductive layers changed the optical properties of the device, and changing the electrical drive could move the device back toward a prior state or to a different state. (EX1010, 128; EX1011, 75-76.) It was also well understood that electrochromic devices were not limited to simple on/off operation, but could be driven to intermediate optical states and could maintain a selected condition through open-circuit memory with little or no continued power. (EX1010, 128; EX1011, 75-76.) Electrochromic devices could continuously change transmission, and optical density could be continuously changed by varying voltage (EX1008, 73260K-3), and online light-transmission control was already known to use a microcontrolled system that monitors electrical behavior during switching. (EX1009, 1572-1573.)

39. In practical terms, it was well known before the effective filing date of the ’870 Patent that seals were essential for long term durability. Such sealing means hermetically sealing the media within the device so that it is prevented escaping therefrom and is also shielded from the external environment. (EX1017, 1:23-26) The seal also assists to prevent electrodes or conductive coatings from contacting one another and thus decrease the chance of short-circuiting the system. (EX1017,1:58-67) The performance requirements for a perimeter seal used in an electrochromic device have been well known. The seal must have good adhesion to

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glass, metals and metal oxides, must have low permeabilities for oxygen, moisture vapor and other detrimental vapors and gases, and must not interact with or poison the electrochromic it is meant to contain and protect. Because of their lower processing temperatures, thermoplastic, thermosetting or UV curing organic resin sealing systems are preferred. Because of their excellent adhesion to glass, low oxygen permeability and good solvent resistance, epoxy-based organic resin sealing systems are preferred. These epoxy resin seals may be UV curing or thermally curing. (EX1018, 7: 31-58) Other important considerations for sealing materials include their ability to strongly adhere to the respective surfaces involved and having a coefficient of thermal expansion that matches the materials involved. (EX1018, 3:24-32).

40. The techniques used to apply and manufacture such seals were also well known before the effective date of the '870 Patent. The perimeter seal member can be applied by means commonly used in the industry such as by silk-screening or dispensing. The sealing material could be applied to one substrate or both. It is also common to offset the two layers either physically (EX 1018, Fig. 2,3). Alternatively, the sealing material could be applied via through cutting or ablation of the layers. (EX1004).

41. For example, the prior art teaches forming offset edge regions by cutting portions of substrates and conductive coatings so that conductive electrode

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surfaces are exposed for busbar attachment, including by mechanical cutting or laser cutting. (EX1004, 5:67-6:5, 8:58-63.) The prior art also teaches removing cut portions and removing switching material remaining on an uncut substrate to expose the conductive surface. (EX1004, 9:32-41.) In addition, electrochromic edge seals could be implemented using known curable seal materials and barrier geometries, including thermoplastic and thermoset materials, epoxy-containing materials, UV-curable materials, and temperature-curable materials. (EX1004, 16:63-17:30; EX1005, 6:42-65, 7:10-24.) Thus, before the alleged invention, a person of ordinary skill in the art would have understood that electrochromic-device edges could be cut or otherwise patterned to expose electrode regions, connected using busbars, and protected using curable seals or barrier materials configured to adhere to device layers and block oxygen and moisture.

42. A person of ordinary skill in the art would have understood, as rudimentary knowledge, that an edge seal is required to protect the electrochromic device from the environment and other impurities which could damage the device. Moreover, a person of ordinary skill in the art would have understood that the use of epoxy and related materials as established sealant materials and that their use involves either UV or thermal curing steps. The sealant is dispersed so that it covers the side of the electrochromic device and a portion of the electrode layers. Lastly, this construction is facilitated by offsetting the two substrates physically or through

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cutting portions away. A person of ordinary skill in the art would have understood, as rudimentary knowledge, that the application of such seals in this manner were well-known and conventional.

43. The Background of the ’870 patent also identifies edge protection as a known practical concern for laminated electrochromic films. It explains that, for smart-window applications, electrochromic materials needed to be integrated with a glass substrate, and that the integration process usually required sandwiching the electrochromic film between two glass panels with interlayers such as polyvinyl butyral (PVB) and SentryGlas, followed by pressing and heating. (EX1001, 1:42-48.) The Background further states that interlayers may contain additives for chemical and physical property modifications, and that those additives can infiltrate multilayer electrochromic films and adversely affect performance and lifetime. (EX1001, 1:48-54.) Thus, the ’870 patent’s own Background confirms that protecting laminated electrochromic films from interlayer infiltration was a recognized design concern.

VIII. OVERVIEW OF THE ’870 PATENT

A. Specification and Claims

44. The ’870 patent relates to electrochromic devices with edge protection, including electrochromic films used in laminated smart-window structures. The patent explains that electrochromism involves “a reversible change in optical

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properties" when a potential is applied, and that electrochromic materials can reversibly change color through electrochemical oxidation-reduction reactions caused by an electric field. (EX1001, 1:23-30.) The patent identifies smart-window technology as one application, where electrochromic films are integrated with glass substrates for serviceability. (EX1001, 1:40-45.)

45. The '870 patent describes the problem it was trying to solve. The specification explains that electrochromic films are "typically sandwiched between two glass panels, with interlayers (e.g., PVB, SentryGlas, etc.) disposed between the electrochromic film and the glass panels." (EX1001, 1:40-44.) The patent further explains that, during lamination, "the glass panels, interlayers, and electrochromic film are pressed together and heated so that the interlayers are cured and the electrochromic film is fixed between the two glass panels." (EX1001, 1:44-48.) According to the '870 patent, "additives within the interlayers can infiltrate into multilayer electrochromic films and adversely affect the electrochromic films," and "[a]s a result, the performance and lifetime of the electrochromic films can be severely compromised." (EX1001, 1:48-53.)

46. Figure 2 shows a schematic for a typical multilayer electrochromic film that can be affected by such interlayer infiltration during lamination. Electrochromic film 200 includes first and second transparent substrates 202 and 204, such as glass, arranged in spaced, parallel relation. (EX1001, 4:40-47.) A first transparent

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electrically conductive film 206 is deposited on interior surface 208 of first substrate 202 to act as an electrode, and a second transparent electrically conductive film 210 is deposited on interior surface 212 of second substrate 204 to act as an electrode. (EX1001, 4:52-56.) Between those electrode-forming conductive films, the device includes electrochromic material layer 214 on first electrically conductive film 206, charge storage layer 218 on second electrically conductive film 210, and electrolyte layer 222 between the electrochromic material layer and charge storage layer. (EX1001, 5:8-16, 5:47-61.)

47. The ’870 patent states that it sets out to solve the infiltration problem through “edge protection to protect the edges of the electrochromic film from being infiltrated by undesired materials as well as oxygen and moisture.” (EX1001, 1:60-64.) Although the specification provides several examples of edge protection, I understand Figures 8 and 9 to be the most relevant embodiments for the challenged claims. Figure 8 depicts an unlaminated electrochromic film with edge protection, and Figure 9 depicts a laminated electrochromic film with edge protection.

48. Annotated Figure 9 below depicts electrochromic device 900 including substrates 902 and 904, for example glass panels, shown in green; first and second sides 901a and 901b, shown in blue; and edge protection materials 905 and 915, for example epoxy, shown in yellow. (EX1001, 8:57-65.) The patent explains that, similar to Figure 8, the electrochromic film in Figure 9 includes two sides 901a and

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901b, “one as an anode and the other as a cathode.” (EX1001, 8:57-61.) In my opinion, a person of ordinary skill in the art would understand the anode and cathode sides 901a and 901b to correspond to the opposing electrode-side portions of the electrochromic film. To manufacture electrochromic device 900, the ’870 patent explains that “[t]he edges of the electrochromic film 901a and 901b are covered by an edge protection material, e.g., a layer of epoxy 905 and 915.” (EX1001, 8:61-64.) The epoxy 905/915 is then cured with heat or ultraviolet light, enabling the epoxy to work as “an effective oxygen and moisture blocker.” (EX1001, 8:63-65.) The patent further explains that the electrochromic film can then be laminated in interlayer 903 between glass substrates 902 and 904. (EX1001, 8:65-67.) In the annotated figure, the yellow edge protection material illustrates the material the patent relies on to protect the edges of the electrochromic film from oxygen, moisture, and undesired materials.

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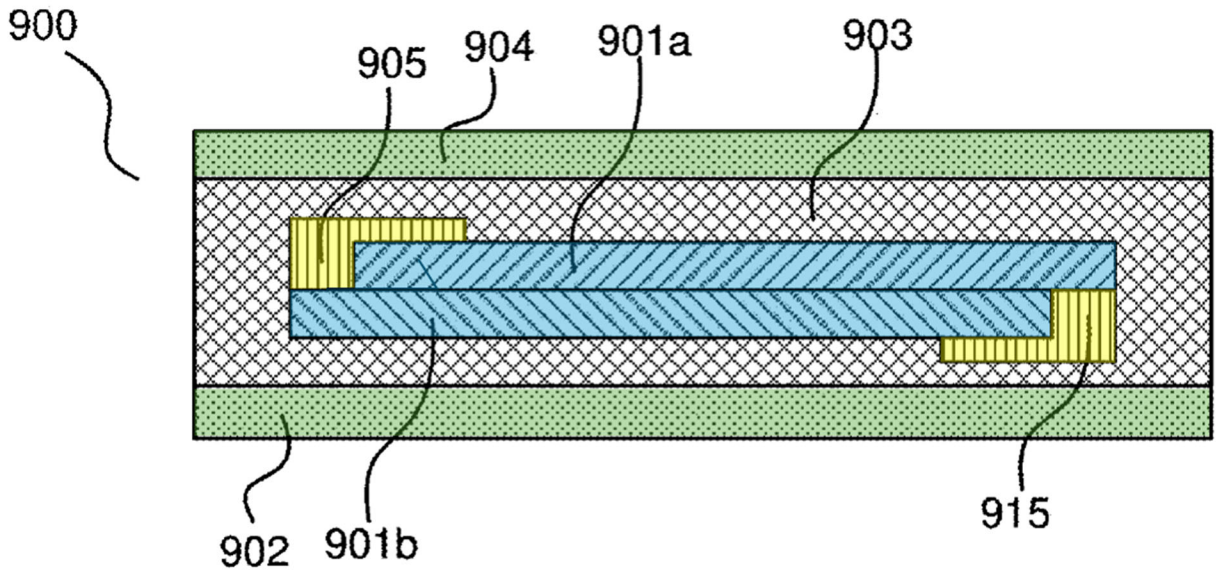
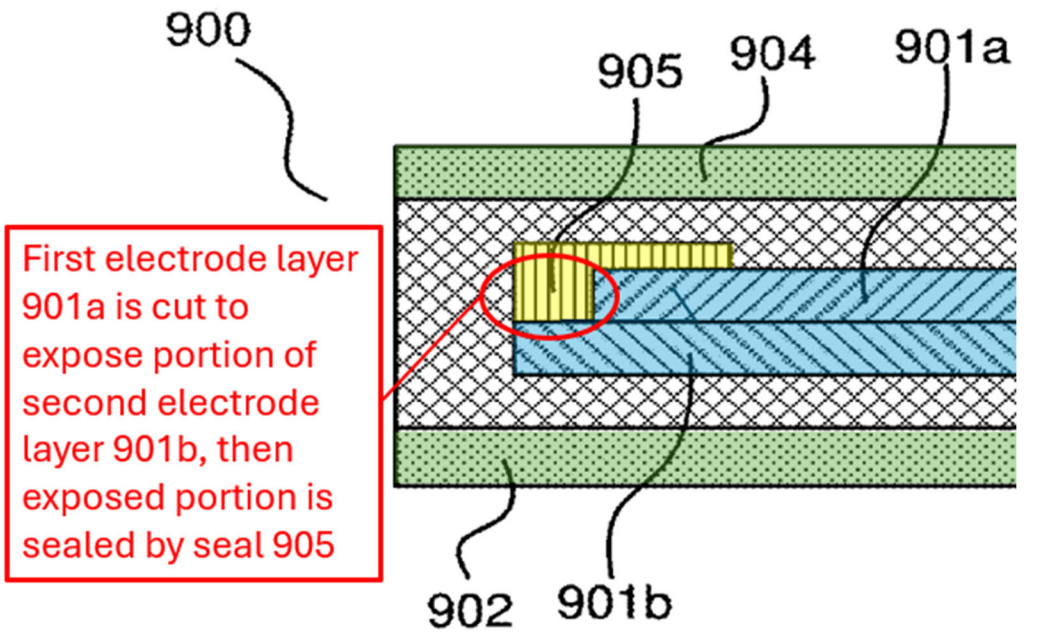


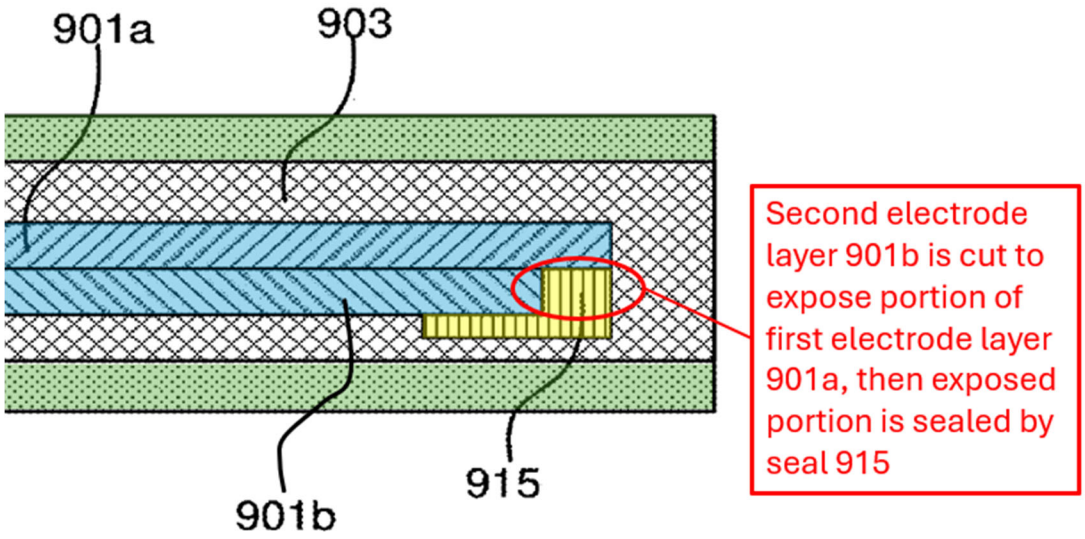
FIG. 9

49. Claim 1 is the only independent claim. Claim 1 is directed to an edge-protected electrochromic device and recites an electrochromic film comprising first and second electrode layers facing each other. Claim 1 further recites that an edge of the first electrode layer is cut such that a portion of an inner surface of the second electrode layer is exposed.

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50. Claim 1 also recites that an edge of the second electrode layer is cut such that a portion of an inner surface of the first electrode layer is exposed, with the edge of the first electrode layer and the edge of the second electrode layer being opposing edges. (EX1001, 9:22-35.)



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51. In my opinion, a person of ordinary skill in the art would understand those limitations to require exposed inner electrode surfaces at opposing edges of the device.

52. Notably, the '870 specification never mentions or describes cutting electrodes or any other layers of the electrochromic film, let alone cutting electrodes to expose portions of the other electrodes. The specification describes edge protection material covering edges of the electrochromic film, including epoxy 905 and 915 in Figure 9, but it does not describe forming those edges by cutting an electrode layer to expose an inner surface of the opposing electrode layer. (EX1001, 8:57-67.) From a technical perspective, that omission is significant because cutting a thin electrode layer to expose an inner surface of an opposing electrode is a different manufacturing operation than laminating layers together and covering their edges with epoxy.

53. Claim 1 further recites first and second edge protection materials that seal the exposed portions of the inner surfaces of the first and second electrode layers, respectively. (EX1001, 9:22-35.) A person of ordinary skill in the art would understand those edge protection materials to correspond generally to the yellow edge protection material shown in the annotated Figure 9, such as epoxy 905 and 915. The dependent claims add further edge-protection configurations. For example, the edge protection materials can seal side surfaces of the first and second electrode

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layers and can extend around the edge to portions of external surfaces of the first and second electrode layers.

54. The ’870 patent touts the benefits of edge protection as protecting the electrochromic film from infiltration by unwanted additives and exposure to materials such as oxygen and moisture, thereby improving the performance and lifetime of the electrochromic film. (EX1001, 1:60-64, 2:4-15, 8:63-65.) In my opinion, a person of ordinary skill in the art would understand the patent’s disclosed edge-protection concept to be the use of materials such as epoxy at electrochromic-film edges to block oxygen, moisture, and undesired interlayer materials. As I explain in later sections of my declaration, prior art electrochromic-device references disclosed these types of edge-protection and sealing features.

B. Prosecution History

55. I understand that the prosecution history of the ’870 patent was brief and did not include any prior-art-based rejection of the issued claims. I understand that the Examiner did not reject the claims under 35 U.S.C. § 102 or § 103, and did not apply any prior-art reference against the limitations that ultimately issued in claim 1. Instead, I understand that the Examiner’s rejections were limited to issues under 35 U.S.C. § 112(b).

56. I understand that the Examiner’s first rejection stated that claims 1-12 lacked antecedent basis for the claimed “second electrochromic film.” (EX1002,

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pp.547-550.) I further understand that Applicant responded by correcting that antecedent-basis issue, including by changing "electrochromic film" to "electrode layer." (EX1002, pp.559-565.) I also understand that the Examiner later issued a final terminology-based rejection concerning the phrase "a first edge of the first electrode layer," and that Applicant responded by again correcting the claim language. (EX1002, pp.650-654; 672-678.)

57. I understand that, after Applicant's response, the Examiner allowed the claims. I further understand that the Examiner's stated reason for allowance was that the prior art did not disclose the claimed edge protection. In particular, I understand that the Examiner stated that the prior art failed to disclose "a first edge protection material sealing the exposed portion of the inner surface of the second electrode layer, and a second edge protection material sealing the exposed portion of the inner surface of the first electrode layer." (EX1002, pp.705-711.)

C. Examiner Error

58. I understand that U.S. Patent No. 9,810,963 to Gauthier is not listed on the face of the '870 patent, but that Gauthier's corresponding PCT publication, WO 2014/134714 A2, is listed on the face of the '870 patent. I also understand that the Gauthier PCT publication was submitted in an Information Disclosure Statement during prosecution. (EX1002, pp.30-35.) Based on my review of the prosecution history, I understand that the Examiner did not apply Gauthier or the corresponding

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Gauthier PCT publication in a prior-art rejection of the original claims of the '870 patent.

59. I understand that the Examiner allowed the claims based on the view that the prior art failed to disclose the two edge-protection limitations: first, a first edge protection material sealing the exposed portion of the inner surface of the second electrode layer; and second, a second edge protection material sealing the exposed portion of the inner surface of the first electrode layer. (EX1002, pp.705-711.) From a technical perspective, I disagree with that view because, as I explain in detail below, Gauthier discloses a closely analogous electrochromic film structure with opposing electrode layers, offset exposed electrode regions, and seals applied at those exposed edge regions.

60. In particular, as discussed in the later invalidity analysis, Gauthier discloses an electrochromic device including two electrode-bearing substrates with switching material between them, laminated in an interlayer between glass sheets. Gauthier also discloses offset edge regions formed by removing or cutting portions of the substrate/electrode structure to expose conductive surfaces of the opposite electrode-bearing substrate. Gauthier further discloses first seals 64 positioned at the exposed offset edge regions, adjacent to the switching material and exposed conductive coating/busbar region. In my opinion, those disclosures correspond to

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the same general edge-protection concepts that the Examiner identified as missing from the prior art. (EX1004, 6:41-7:3, 10:54-11:5.)

61. Accordingly, from a technical perspective, the Examiner did not address prior-art disclosures in Gauthier that are highly material to the issued claim limitations concerning edge protection material sealing exposed portions of inner electrode surfaces. My opinions below explain why Gauthier, alone or in combination with other references, discloses or would have rendered obvious the challenged limitations.

IX. GROUND 1: CLAIMS 1-12 ARE INVALID FOR LACK OF WRITTEN DESCRIPTION

62. I have reviewed claims 1-12. A POSA would have found these claims to be invalid for lacking a proper written description.

63. Claim 1 recites, among other things, that "an edge of the first electrode layer is cut such that a portion of an inner surface of the second electrode layer is exposed," and that "an edge of the second electrode layer is cut such that a portion of an inner surface of the first electrode layer is exposed," with those edges being opposing edges. Claims 9 and 10 similarly recite that the layer of electrochromic material, the layer of electrolyte material, and the layer of charge storage material are "cut in a same way" as the edge of the first or second electrode layer to expose a portion of the inner surface of the opposite electrode layer.

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64. In my opinion, these "cut to expose" limitations describe a specific manufacturing and structural concept. They require more than merely having two electrode layers arranged so that portions of inner surfaces are exposed. They require that an edge of one electrode layer be cut in a manner that exposes a portion of the inner surface of the opposing electrode layer, and they further require corresponding cutting of the electrochromic material, electrolyte material, and charge storage material for claims 9 and 10. A person of ordinary skill in the art would have understood this to be a distinct process and structure from simply laminating layers together with pre-existing offsets.

65. I have reviewed the specification of the '870 patent. Other than the claim language itself, I do not see disclosure in the specification describing cutting an edge of the first electrode layer to expose a portion of an inner surface of the second electrode layer, or cutting an edge of the second electrode layer to expose a portion of an inner surface of the first electrode layer. I also do not see disclosure describing cutting the electrochromic material layer, electrolyte material layer, and charge storage material layer in the same way as the electrode edge to expose the inner surface of the opposite electrode layer. In my opinion, the written description does not explain how such cutting would be performed, what tool or process would be used, how the thin electrode layers would be cut without damaging the opposing

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electrode or intermediate layers, or how the resulting exposed inner electrode surfaces would be formed.

66. The ’870 specification instead describes forming electrochromic-film structures through deposition and lamination processes. For example, the patent describes an electrochromic device having first and second transparent substrates, transparent electrically conductive films on interior surfaces of those substrates acting as electrodes, an electrochromic material layer, a charge storage layer, and an electrolyte layer between them. (EX1001, 4:39-5:65.) The patent further describes fabricating electrochromic films using known deposition or coating techniques, such as sputtering, chemical vapor deposition, physical vapor deposition, plasma-enhanced chemical vapor deposition, spray coating, slot-die coating, dip coating, spin coating, and printing. (EX1001, 4:28-35.) Those disclosures would not have conveyed to a person of ordinary skill that the inventor possessed the later-claimed “cut to expose” electrode-edge structures.

67. The edge-protection embodiments in the ’870 patent likewise focus on placing edge protection material around laminated or unlaminated electrochromic films, not on cutting electrode layers to expose inner surfaces of the opposing electrode layers. For example, the patent describes placing stripes of edge seal material on glass panels and laminating an electrochromic film between interlayer-substrate portions. (EX1001, 6:35-7:11.) The patent also describes edge protection

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material covering joints and edges of electrochromic films, such as epoxy covering the joint and edges of two electrochromic films in Figure 6, and epoxy edge protection materials 805/815 and 905/915 in Figures 8 and 9. (EX1001, 7:12-24, 7:35-8:16, 8:57-65.) These disclosures address sealing and protecting edges from oxygen, moisture, and undesired materials, but they do not describe cutting one electrode layer so as to expose an inner surface of the opposing electrode layer.

68. The '870 patent expressly describes the technology as relating to protecting edges of electrochromic films fabricated by roll-to-roll processes and later laminated between substrates. Specifically, the patent states that "[t]his specification describes protecting edges of an electrochromic film that is usually fabricated by a roll-to-roll process with low cost" and explains that electrochromic films are laminated between substrates, such as glass panels, in actual applications. (EX1001, 8:54-62.) A person of ordinary skill in the art would have understood this disclosure as directed to low-cost production and lamination of electrochromic films with edge protection, not as teaching a post-formation cutting operation that selectively cuts electrode and electrochromic-stack layers to expose inner electrode surfaces.

69. In my opinion, when a person of ordinary skill reads the '870 patent's disclosure, the person would not understand the disclosure as necessarily requiring that the exposed portions of the inner electrode surfaces were formed by cutting a completed electrode layer or completed electrochromic stack. An offset edge

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structure can be produced in more than one way. For example, exposed portions of inner surfaces may be formed by assembling or registering pre-formed layers with different lateral extents, or by positioning layers relative to one another so that one layer overhangs another. The '870 patent does not describe a step of cutting an electrode layer, electrochromic material layer, electrolyte layer, or charge-storage layer to expose an inner electrode surface. Thus, in my opinion, the '870 patent's disclosure of exposed portions of inner electrode surfaces would not have conveyed to a person of ordinary skill that the inventors possessed the specific later-claimed approach of cutting the electrode layers, or cutting the electrochromic, electrolyte, and charge-storage layers in the same way as the electrode edges, to expose those inner electrode surfaces. (EX1001, 6:35-7:11, 8:54-62.)

70. By contrast, if the exposed inner electrode surfaces were formed by selectively cutting portions of thin transparent electrode layers and associated electrochromic, electrolyte, and charge-storage layers, a person of ordinary skill would have understood that the process would need to be controlled so that the desired layers are removed while the opposing inner electrode surface remains intact. Transparent conductive films such as ITO are typically thin and can be brittle or susceptible to cracking, edge defects, debris generation, or delamination when cut. Cutting through one electrode-side stack while preserving the opposing inner electrode surface would require careful control to avoid damaging the opposing

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electrode or creating conductive debris that could cause shorts or nonuniform switching. The ’870 specification does not describe any such cutting technique, process control, tool, laser-cutting method, masking approach, or debris/short mitigation strategy.

71. I also understand that the ’870 patent issued from Application No. 18/606,980, filed March 15, 2024, and claims priority through continuation applications to earlier applications filed in 2023 and 2018. I have been asked to consider whether the upstream disclosures show possession of the “cut to expose” limitations. Based on my review, I do not see technical disclosure in the common specification of the upstream applications describing cutting an edge of one electrode layer to expose an inner surface of the opposing electrode layer, or cutting the electrochromic material, electrolyte material, and charge storage material in the same way as the electrode edge. In my opinion, the same technical deficiency described above applies to the upstream disclosures because they disclose edge protection and lamination concepts, not the claimed “cut to expose” structures.

72. I understand that the “cut to expose” language appears in the claims of the application that issued as the ’870 patent. From a technical perspective, however, the presence of that language in the claims does not change my opinion about what the specification itself conveys to a person of ordinary skill in the art. The specification does not provide the technical description that a person of ordinary skill

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would expect for a claimed structure made by cutting electrode and electrochromic-stack layers to expose inner surfaces of the opposing electrode layers.

73. In my opinion, the lack of disclosure is material for all challenged claims because claim 1 is the only independent claim and claims 2-12 depend directly or indirectly from claim 1. Claims 9 and 10 also add further "cut in a same way" requirements for the electrochromic material, electrolyte material, and charge storage material. For the technical reasons discussed above, a person of ordinary skill in the art would not have understood the '870 specification to show possession of those cut-layer structures.

74. [intentionally left blank]

75. [intentionally left blank]

X. GROUND 2: CLAIMS 1-12 ARE OBVIOUS OVER GAUTHIER

A. Overview of Gauthier

76. I have reviewed Gauthier. In my opinion, Gauthier sets out to solve the same type of problem addressed by the '870 patent: protecting sensitive switchable or electrochromic film materials from environmental exposure and degradation. Gauthier teaches an edge-seal system for protecting layered switchable films. Gauthier explains that a switchable film generally includes two electrode substrates with switchable material between them, and discloses a "seal around the perimeter of the switchable material to keep it separated from water, air, oxygen or other

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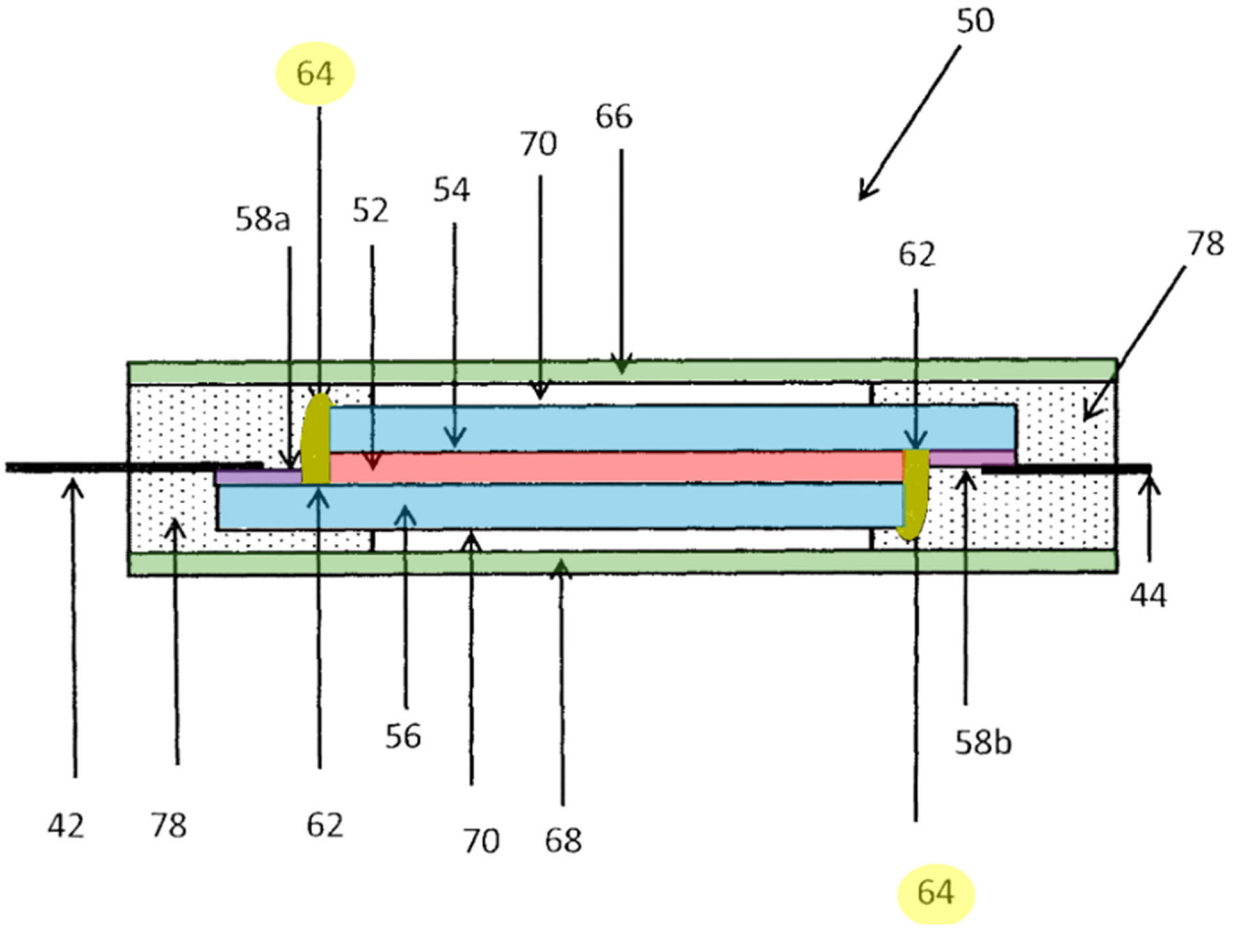
aspects of the external environment." (EX1004, 1:13-22.) Gauthier further explains that this separation "may be beneficial in preserving function, or preventing degradation or diminished performance." (EX1004, 1:22-24.)

77. Gauthier's layered structure closely tracks the architecture recited in the challenged claims of the '870 patent. Gauthier discloses a sealed switchable film, including electrochromic embodiments, comprising first and second substrates, such as glass or other transparent material, first and second electrodes disposed inside the first and second substrates, and switching material disposed between the first and second electrodes. (EX1004, 5:5-17, 10:17-28.) Gauthier further teaches that a first seal is disposed along an exposed edge of the switching material, is compatible with the switching material, and may adhere to the electrodes. (EX1004, 5:5-22.) Gauthier also teaches that a second seal may be used to encapsulate the first seal. (EX1004, 5:5-22.)

78. An embodiment of Gauthier's encapsulated switchable film is illustrated in annotated Figure 6 below. In Figure 6, switching material 52, shown in red, is positioned between first and second substrates 54 and 56, shown in blue. (EX1004, 10:54-59.) Substrates 54 and 56 include conductive coatings that contact switching material 52. (EX1004, 10:57-59.) A person of ordinary skill in the art would have understood the substrates 54 and 56 together with their respective conductive coatings to correspond to electrode-bearing substrate structures. Portions

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of the substrates and switching material are removed at opposite edge regions to expose conductive coating surfaces on the interior sides of the top and bottom substrate/electrode structures. (EX1004, 10:59-61.)



EX1004, Figure 6 (annotated)

79. Still referring to annotated Figure 6, busbar 58a, shown in purple, is attached to the exposed inner conductive surface associated with top substrate 54, and busbar 58b, also shown in purple, is attached to the exposed inner conductive

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surface associated with bottom substrate 56. In this way, the busbars contact the conductive coatings on substrates 54 and 56. (EX1004, 10:54-59.) First seals 64, shown in yellow, are applied to the remaining exposed edge regions of the top and bottom substrate/electrode structures. Specifically, first seals 64 are applied in spaces 62 between the busbars and the switching material on the inner surfaces of both substrate/electrode structures, adjacent to the cut edges of the switching material and the opposite substrate/electrode structure. (EX1004, 10:61-64.)

80. Gauthier also discloses transparent layers 66 and 68, such as glass, shown in green in the annotated figure, that encapsulate the switchable film. In Figure 6, transparent layers 66 and 68 and second seal 78 encapsulate substrates 54 and 56, switching material 52, busbars 58a and 58b, and first seals 64 at both edge regions. (EX1004, 10:64-11:5.) Gauthier further explains that the second seal is separated from the switching material by first seal 64. (EX1004, 10:64-11:5.) In my opinion, this structure is technically similar to the '870 patent's disclosed laminated electrochromic device with edge protection material around electrochromic-film edges.

81. Gauthier explains how the offset-edge structure of Figure 6 may be made. Gauthier teaches that switchable material may first be coated onto a conductive coating of a substrate/electrode, and a second substrate/electrode may then be laminated on top with its conductive coating side in contact with the

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switching material to form a switchable-film sandwich structure. (EX1004, 24:39-54.) Gauthier teaches that the sandwich structure is cured and then cut to size. (EX1004, 24:54-57.) A person of ordinary skill in the art would have understood this disclosure as describing formation of a layered switchable-film structure and subsequent cutting operations used to define the device structure.

82. Once the switchable-film sandwich structure is cured, Gauthier teaches that the substrate and switchable material may be cut to expose conductive electrode surfaces. Gauthier discloses different ways to cut the first and second substrate/electrode structures to form offset edges and remove switching material, thereby providing a busbar platform directly on the transparent conductive layer on the interior side of the substrate/electrode structure. (EX1004, 5:67-6:5.) For example, Gauthier teaches mechanical cutting using items such as scissors or a knife. (EX1004, 8:58-67.) Gauthier also teaches laser cutting through the upper substrate/electrode, conductive coating, and switching material without cutting through or damaging the lower conductive coating and lower substrate/electrode. (EX1004, 5:59-6:5, 8:58-67.) In my opinion, these offset cuts expose conductive electrode surfaces in the same general manner recited in the ’870 patent claims.

83. Gauthier further teaches that busbars may be applied to exposed first and second conductive surfaces of the substrate/electrode structures. After those exposed conductive surfaces are formed, the first seal is applied along the cut edge

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of the switching material, the cut edge of the substrate/electrode structure, and the remaining exposed surfaces of the electrodes not covered by the busbars. (EX1004, 30:51-67.) A person of ordinary skill in the art would have understood Gauthier's first seal to protect the exposed cut-edge region while leaving the busbar region available for electrical connection.

84. Gauthier also describes materials suitable for the first seal. Gauthier teaches that seals may be "a thermoplastic, a thermoset, a rubber, a polymer or metal, a metallized tape, or combinations thereof." (EX1004, 16:63-65.) Gauthier further teaches that the seal may be electrically insulating and may be gas impermeable. (EX1004, 17:9-11.) Gauthier also teaches that the first seal may have a low amount of electrical conductivity, or may be overlaid with a metal layer, metal foil, or tape. (EX1004, 3:54-55, 17:66-67.) In my opinion, these disclosures show that Gauthier contemplated seal materials selected for barrier, adhesion, insulation, and in some embodiments controlled conductivity or metal-containing properties.

85. Gauthier's first seal 64 serves the same protective function that the '870 patent attributes to its edge protection material, namely blocking undesired materials, oxygen, and moisture from degrading the switchable or electrochromic film. Gauthier teaches that its seal may isolate the switching material from other components or from the ambient environment, including air and moisture. (EX1004, 6:41-55.) In the offset-edge region, first seal 64 seals the cut edge of switching

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material 52 and contacts the conductive coating of the uncut substrate, helping maintain the seal in position. (EX1004, 5:67-6:5, 10:51-60.) Gauthier further teaches selecting seal materials for adhesion to contacted surfaces, including substrates, conductive layers, and electrodes, and for barrier properties, gas impermeability, water/moisture resistance, and water/moisture impermeability. (EX1004, 16:64-17:16.) In my opinion, Gauthier therefore discloses the same core concept relied on in the '870 patent: offset cut edges exposing conductive electrode surfaces, with seal material applied at those exposed edge regions to protect the switchable film.

86. Like the '870 patent, Gauthier teaches that the switchable or electrochromic film may be laminated with heat and pressure between top and bottom glass or transparent substrates. (EX1004, 16:25-45.) Gauthier also teaches that the transparent conductive coatings may include ITO-coated glass or ITO-coated PET, and that "[a] conductive coating may be an electrode of a switchable film." (EX1004, 23:13-30.) In my opinion, a person of ordinary skill in the art would have understood Gauthier's conductive coatings on substrates 54 and 56 to function as electrodes in the switchable-film device.

87. Gauthier also teaches that the second seal may be laminated between glass or transparent substrates to encapsulate the first seal and switching film. Although Gauthier often uses the broader term "switchable film," or "switchable material," its disclosure expressly includes electrochromic implementations.

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Gauthier explains that an active layer may respond to electricity as an "electrochromic active layer," and describes electrochromic active layers in which compounds behave as a redox pair when electricity is applied. (EX1004, 19:64-20:29.) In my opinion, a person of ordinary skill in the art would have understood Gauthier as directly relevant to electrochromic devices of the type described and claimed in the '870 patent.

B. Claim Element Analysis

1. Claim 1

a) [1.pre] An electrochromic device comprising:

88. To the extent the preamble is limiting, in my opinion Gauthier discloses an electrochromic device. Gauthier is directed to layered switchable devices, including switchable films used in optical filters and laminated glass. (EX1004, 1:10-13, 1:60-64.) Gauthier explains that a switchable film generally includes two substrates with switchable material between them, and that a seal may be provided around the perimeter of the switchable material "to keep it separated from water, air, oxygen or other aspects of the external environment." (EX1004, 1:13-22.) Gauthier further explains that this separation "may be beneficial in preserving function, or preventing degradation or diminished performance." (EX1004, 1:22-24.)

89. Although Gauthier often uses the broader term "switchable film" or "switching material," a person of ordinary skill in the art would have understood Gauthier's disclosure to include electrochromic devices. Gauthier explains that an

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active layer may alter light transmittance in response to a stimulus, including electricity, and identifies an active layer responsive to electricity as "an electrochromic active layer." (EX1004, 19:64-20:8.) Gauthier further describes electrochromic active layers in which compounds behave as a redox pair when electricity is applied: one compound is electrochemically oxidized from a colorless state to a colored state, while another compound is electrochemically reduced from a colorless state to a colored state. (EX1004, 20:14-29.) That is a direct description of electrochromic operation.

90. Gauthier also describes applying electrical potential to electrodes to cause electrochemical switching. For example, Gauthier states that, "[t]o electrochemically switch a lens," electrical potential is applied to the electrodes of the film through busbars, causing the switching material to switch. (EX1004, 8:29-32.) Gauthier further states that electrical connectors may be mounted to busbars "to connect the lens to a source of power to facilitate electrochromic switching of the lens." (EX1004, 8:55-57.) A person of ordinary skill in the art would have understood these disclosures as describing an electrochromic device because the optical state of the film is changed by electrically driven electrochemical switching.

91. Accordingly, to the extent the preamble is limiting, it is my opinion that Gauthier discloses an "electrochromic device."

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b) [1.1] an electrochromic film comprising a first electrode layer and a second electrode layer facing the first electrode layer of the electrochromic film,

92. In my opinion, Gauthier discloses an electrochromic film comprising a first electrode layer and a second electrode layer facing the first electrode layer. Gauthier discloses a switchable film having first and second substrates/electrodes with switching material disposed between them and in contact with electrically conductive layers of the substrates/electrodes. (EX1004, 5:5-17.) As I explained above, although Gauthier often uses the broader term "switchable film or "switching material," Gauthier expressly includes electrochromic implementations. (EX1004, 19:64-20:29.)

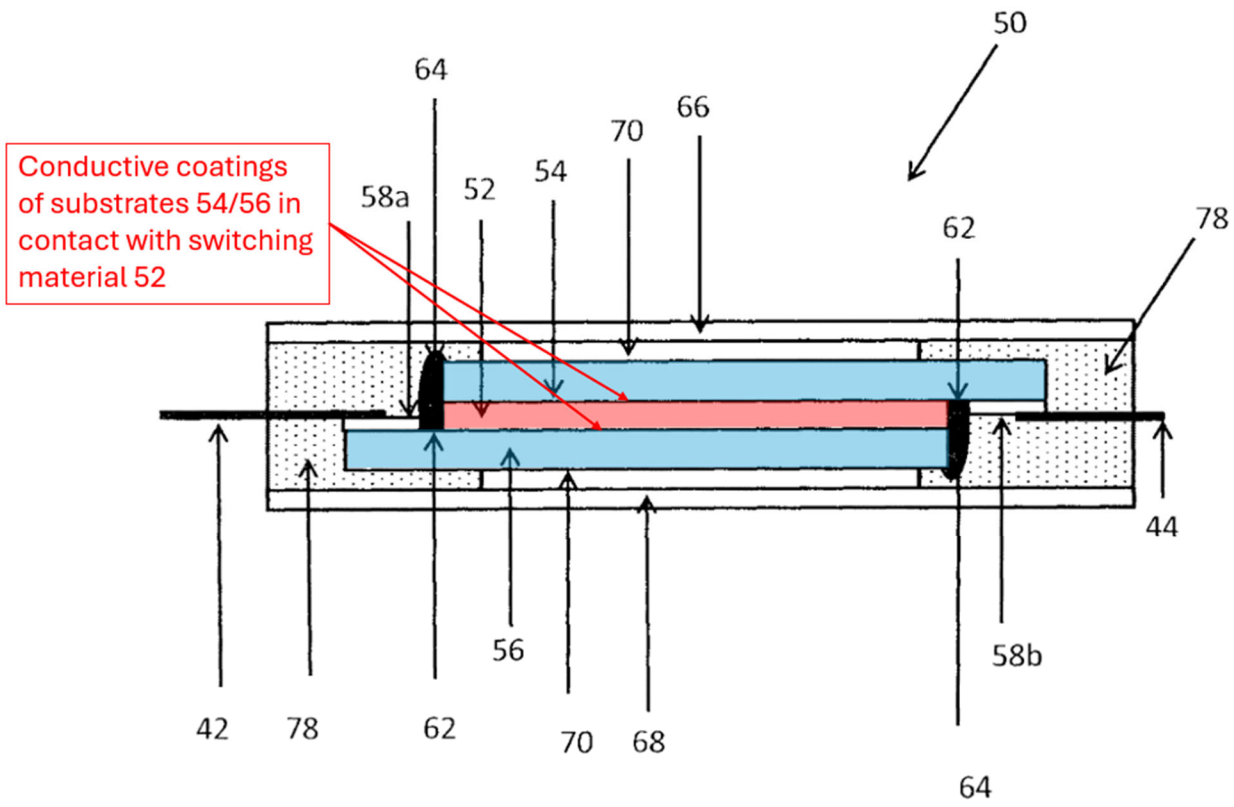
93. Gauthier's electrode layers are the conductive coatings carried on the inward-facing surfaces of the substrates. Gauthier describes an encapsulated switchable film comprising "a layer of switching material between a pair of parallel substrates" and "a first and a second conductive coating or layer (first and second electrode)" disposed on a substrate surface. (EX1004, 10:17-28.) Gauthier further explains that conductive coatings may be transparent and may include transparent conducting oxides such as indium tin oxide (ITO) or fluorine tin oxide (FTO), metal or metal oxide coatings, transparent conducting polymers, or other substantially transparent conductive coatings. (EX1004, 23:13-23.) Gauthier gives examples

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including ITO-coated glass and ITO-coated PET, and then states expressly: "A conductive coating may be an electrode of a switchable film." (EX1004, 23:20-30.)

94. Annotated Figure 6 illustrates this same structure. In the annotated figure below, substrates 54 and 56 are shown in blue, and switching material 52 is shown in red. Gauthier explains that switching material 52 is positioned between first substrate 54 and second substrate 56, and that busbars 58a and 58b contact conductive coatings on substrates 54 and 56. (EX1004, 10:54-59.) Gauthier further states that "the conductive coating is in contact with the switching material 52." (EX1004, 10:57-59.) A person of ordinary skill in the art would have understood from this disclosure that the conductive coatings are on the inward-facing surfaces of substrates 54 and 56, facing each other across switching material 52.

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EX1004, Figure 6 (annotated).

95. In my opinion, a person of ordinary skill in the art would have understood Gauthier's conductive coatings on substrates 54 and 56 to be the claimed first and second electrode layers, respectively. Those conductive coatings face one another across switching material 52, contact the switching material, and receive electrical connection through busbars 58a and 58b. (EX1004, 10:54-61.) Gauthier also teaches that portions of substrates 54 and 56 are removed to expose the conductive coating where the busbars are applied, confirming that the electrically conductive layers are located on the substrate-side surfaces exposed in the offset-edge regions. (EX1004, 10:59-61.)

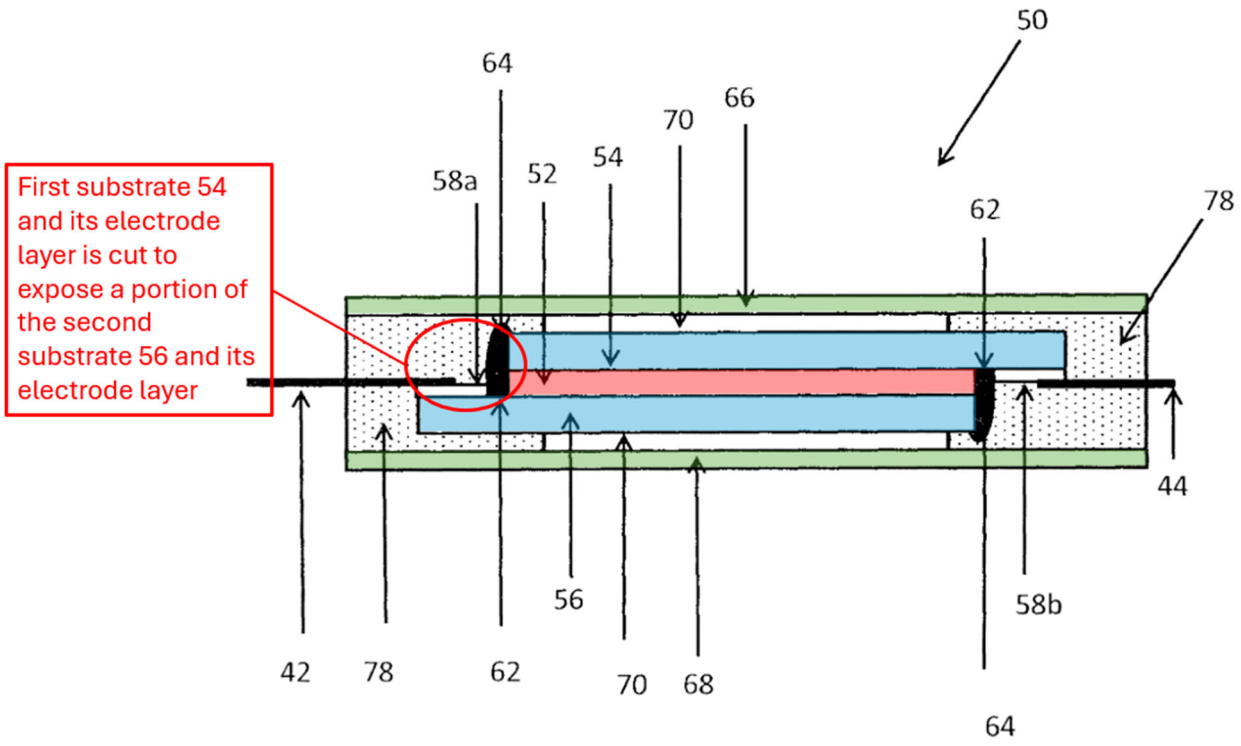
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96. Accordingly, in my opinion, Gauthier discloses an electrochromic film comprising a first electrode layer and a second electrode layer facing the first electrode layer.

c) [1.2] wherein: an edge of the first electrode layer is cut such that a portion of an inner surface of the second electrode layer is exposed, and

97. In my opinion, Gauthier discloses an edge of the first electrode layer is cut such that a portion of an inner surface of the second electrode layer is exposed. As an example, Figure 6 shows an offset-edge structure in which one side of the electrochromic film stack is cut back relative to the opposing side, thereby exposing the conductive coating/electrode layer on the opposing substrate. Gauthier explains that, in Figure 6, portions of substrates 54 and 56 have been removed "to expose the conductive coating where the busbars may be applied." (EX1004, 10:54-61.) Because Gauthier identifies a conductive coating as an electrode of a switchable film, the exposed conductive coating on the opposing substrate corresponds to the exposed portion of the inner surface of the second electrode layer. (EX1004, 23:28-30.)

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EX1004, Figure 6 (annotated);

98. In the annotated Figure 6, the blue structures correspond to substrate/electrode structures 54 and 56, including their conductive coatings. The red structure corresponds to switching material 52, and the green structures correspond to transparent layers 66 and 68. At the left-side offset edge identified in the callout, the upper substrate/electrode structure 54 is cut back relative to the lower substrate/electrode structure 56. A person of ordinary skill in the art would have understood that this offset exposes a portion of the inward-facing conductive coating of the lower substrate/electrode structure 56, which is the conductive electrode surface facing switching material 52.

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99. Gauthier expressly teaches cutting the film stack to create that offset and exposed electrode surface in the area that I circled above. Gauthier discloses both mechanical and laser cutting, and explains that a laser is preferred "to cut only through the upper most substrate and conductive coating, without cutting through or damaging the conductive coating of the lower substrate." (EX1004, 8:58-63.) Gauthier similarly describes cutting a portion of a first substrate, but not a second substrate, thereby "leaving the conductive layer of the second substrate intact." (EX1004, 3:15-20.) After the cut, the substrate/electrode portion is removed, and any switching material remaining on the uncut substrate may be removed to expose the conductive surface. (EX1004, 9:32-41.)

100. Thus, at one offset edge of Figure 6, Gauthier discloses cutting back the upper substrate/electrode structure 54 and its conductive coating while leaving the lower substrate/electrode structure 56 and its conductive coating intact and exposed. In my opinion, a person of ordinary skill in the art would have understood this to disclose an edge of the first electrode layer cut such that a portion of an inner surface of the second electrode layer is exposed.

d) [1.3] an edge of the second electrode layer is cut such that a portion of an inner surface of the first electrode layer is exposed, the edge of the first electrode layer and the edge of the second electrode layer are opposing edges

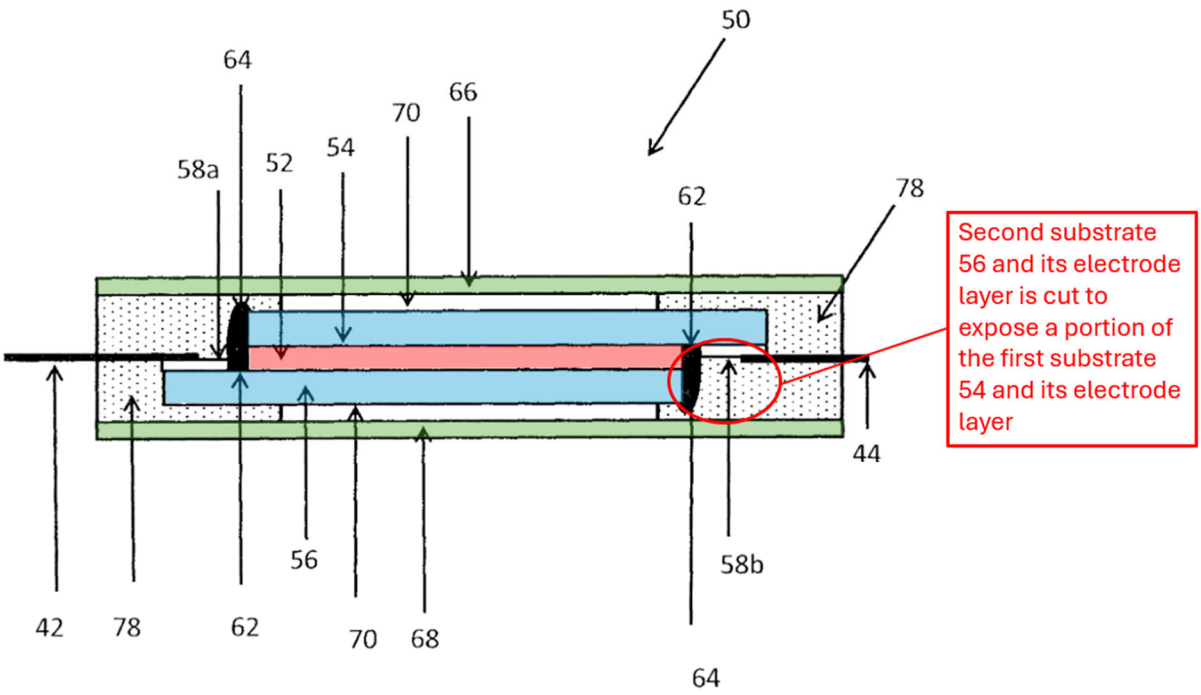
101. In my opinion, Gauthier discloses an edge of the second electrode layer

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cut such that a portion of an inner surface of the first electrode layer is exposed, with that edge opposing the edge discussed for limitation [1.2]. This limitation is the counterpart to limitation [1.2] and is shown at the opposite offset edge of Gauthier Figure 6. As discussed for limitation [1.2], Gauthier teaches offset edge regions in which one side of the film stack is cut back relative to the opposing side, thereby exposing the conductive coating on the opposing substrate/electrode structure. In Figure 6, portions of substrates 54 and 56 have been removed "to expose the conductive coating where the busbars may be applied." (EX1004, 10:54-61.)

102. At the opposite offset edge of Figure 6, the second substrate/electrode structure and its conductive coating are cut back, exposing the inward-facing conductive coating of the first substrate/electrode structure where the corresponding busbar is applied. Because Gauthier identifies the conductive coating as an electrode of a switchable film, the exposed conductive coating corresponds to the exposed portion of the inner surface of the first electrode layer. (EX1004, 23:28-30.)

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EX1004, Figure 6 (annotated).

103. Gauthier expressly teaches that the two cut-back regions are opposing edges. Gauthier describes Figure 6 as showing "the cut edges, busbar and electrical connectors for an encapsulated film with offset edges." (EX1004, 4:53-56.) In the related offset-edge embodiment, Gauthier explains that first substrate 54 and second substrate 56 are "offset along opposing sides 60a and 60b," which "provides for access to the conductive surfaces to apply busbars and electrical connectors." (EX1004, 6:37-40.) A person of ordinary skill in the art would have understood Figure 6 to apply that same offset-edge concept in cross-section, with busbar 58a applied at one exposed conductive surface and busbar 58b applied at the opposing exposed conductive surface. (EX1004, 10:54-61.)

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104. Gauthier's cutting disclosures confirm that these opposing exposed electrode surfaces are created by cutting. Gauthier teaches mechanical and laser cutting, with laser cutting preferred "to cut only through the upper most substrate and conductive coating, without cutting through or damaging the conductive coating of the lower substrate." (EX1004, 8:58-63.) Gauthier also teaches that, after cutting, the cut substrate/electrode portions are removed, and any switching material remaining on the uncut substrate may be removed to expose the conductive surface. (EX1004, 9:32-41.) Applied at the opposite side of the film, a person of ordinary skill in the art would have understood the same process to cut back the second substrate/electrode layer and expose the first conductive coating on the inner surface of the first substrate/electrode layer.

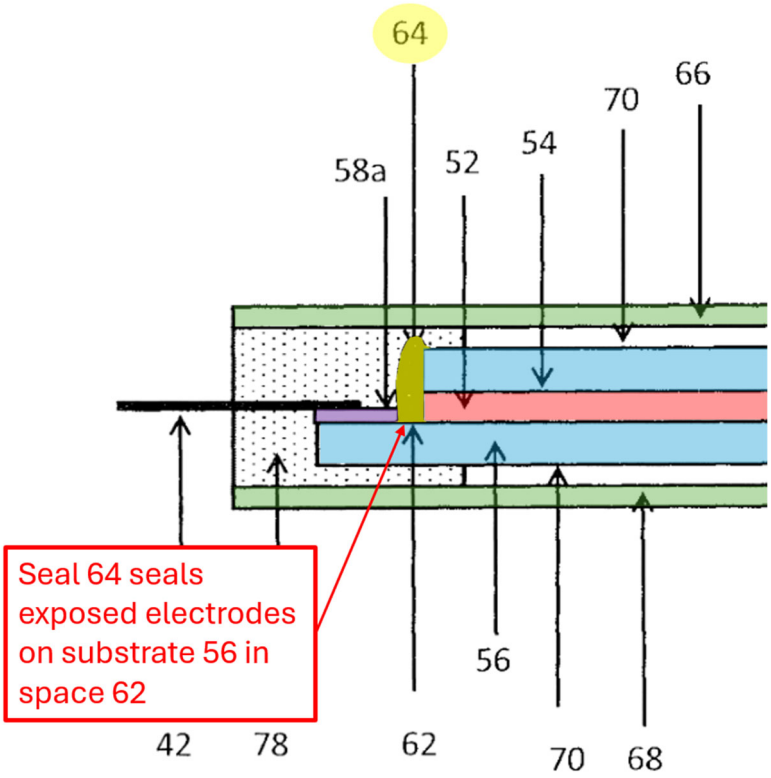
105. Thus, in my opinion, Gauthier discloses opposing offset edges. At one edge, the first electrode layer is cut back to expose the second electrode layer, as discussed for limitation [1.2]. At the opposing edge, the second electrode layer is cut back to expose the first electrode layer. Accordingly, Gauthier discloses or at least renders obvious limitation [1.3].

e) [1.4] a first edge protection material sealing the exposed portion of the inner surface of the second electrode layer; and

106. In my opinion, Gauthier discloses a first edge protection material sealing the exposed portion of the inner surface of the second electrode layer. As I

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explained for limitation [1.2], the left-hand offset edge of Figure 6 exposes the conductive coating on substrate/electrode structure 56. Gauthier's first seal 64, highlighted in yellow in the annotated figure below, is applied to the remaining exposed portion of the inner surface of second substrate/electrode structure 56 not occupied by busbar 58a and seals that exposed portion.



EX1004, Figure 6 (annotated).

107. Gauthier describes that a portion of substrate/electrode structure 54 has been removed "to expose the conductive coating where the busbars [58a] may be applied." (EX1004, 10:54-61.) At the left-hand offset edge, the removed portion exposes the conductive coating on substrate/electrode structure 56. In my opinion, a

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person of ordinary skill in the art would have understood that exposed conductive coating to be the exposed portion of the inner surface of the second electrode layer. Gauthier then applies first seal 64 "in a space 62 between the busbar and switching material, adjacent to the cut edge of the switching material." (EX1004, 10:61-64.) Thus, first seal 64 is located in the same offset edge region as the exposed conductive coating on the substrate/electrode structure and seals that region.

108. Gauthier further confirms that first seal 64 seals the exposed inner surface of substrate/electrode structure 56. Gauthier explains that cutting the substrates to form offset edges and removing switching material provides a busbar platform "directly on the transparent conductive layer on the interior side." (EX1004, 5:67-6:5.) The busbar, such as busbar 58a, may then be positioned on the exposed surface of substrate/electrode structure 56 while leaving space 62 for seal 64. Gauthier explains that the seal is positioned "along the cut edge of the switching material, thereby sealing the switching material, and physically separating the busbar from the switching material." (EX1004, 5:67-6:5, 6:34-36.)

109. Gauthier also states that, along the cut edges, "the first seal contacts the cut edge of the switching material and the conductive coating of the uncut substrate," and that contact with the uncut surface helps maintain the position of the first seal "to ensure a suitable seal for the switching material." (EX1004, 10:51-60.) For the left-hand offset edge of Figure 6, the uncut substrate/electrode structure is

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substrate/electrode structure 56, and its conductive coating is the inner surface exposed on the second electrode layer. In my opinion, this disclosure shows that first seal 64 contacts and seals the exposed inner conductive electrode surface of substrate/electrode structure 56.

110. Gauthier's other descriptions of its seal confirm the same mapping. Gauthier discloses a method of sealing a switchable film by "disposing a first seal in contact with an electrode and adjacent to the switching material." (EX1004, 2:43-47.) Gauthier also teaches selecting seal materials for adhesion to contacted surfaces, including a "substrate," "conductive layer," "electrode," and "switching material," and for barrier properties, including gas impermeability and water/moisture resistance or water/moisture impermeability. (EX1004, 16:64-17:16.) In my opinion, these are the same types of protective functions attributed to the '870 patent's edge protection material.

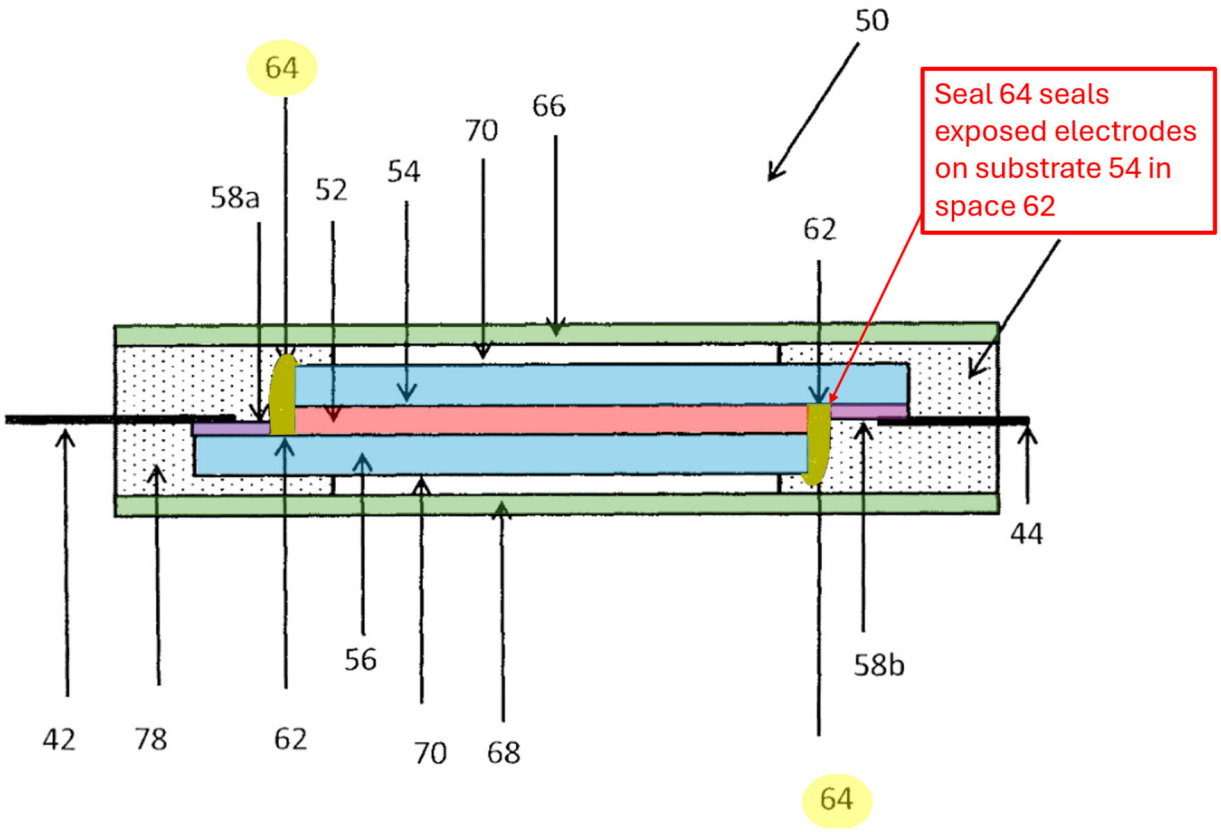
111. Accordingly, in my opinion, Gauthier's first seal 64 at the left-hand offset edge is the claimed first edge protection material. It is applied at the exposed electrode region created by the offset cut, between the busbar and the cut portion of the switching material, contacts the conductive coating of substrate/electrode structure 56, and seals the exposed edge region including the exposed portion of the inner surface of the second electrode layer. Gauthier therefore discloses limitation [1.4].

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f) [1.5] a second edge protection material sealing the exposed portion of the inner surface of the first electrode layer.

112. In my opinion, Gauthier discloses a second edge protection material sealing the exposed portion of the inner surface of the first electrode layer. The analysis for limitation [1.4] applies equally to limitation [1.5] because Gauthier provides two corresponding offset cut regions and two corresponding first seals 64. As illustrated in annotated Figure 6 below, at the right-hand offset edge, the second electrode layer is cut back to expose the conductive coating on the first substrate/electrode structure 54, and the right-hand first seal 64 is applied at that exposed edge region between the busbar, such as busbar 58b, and the switching material. (EX1004, 10:54-64.)

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EX1004, Figure 6 (annotated).

113. Gauthier teaches that portions of first and second substrates/electrode structures 54 and 56 are removed "to expose the conductive coating where the busbars may be applied." (EX1004, 10:54-61.) Gauthier also teaches that first seal 64 is applied "in a space 62 between the busbar and switching material, adjacent to the cut edge of the switching material." (EX1004, 10:61-64.) At the right-hand offset edge, a person of ordinary skill in the art would have understood that the exposed conductive coating is the inward-facing conductive coating of substrate/electrode structure 54, corresponding to the exposed portion of the inner surface of the first electrode layer.

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114. Gauthier further teaches that first seal 64 contacts the conductive coating of the uncut substrate/electrode structure and helps maintain the position of the seal "to ensure a suitable seal for the switching material." (EX1004, 10:51-60.) Gauthier also teaches that its seal materials may adhere to substrates, conductive layers, electrodes, and switching material, and may provide barrier properties including gas impermeability and water/moisture resistance or water/moisture impermeability. (EX1004, 16:64-17:16.) In my opinion, these disclosures confirm that the right-hand first seal 64 performs the same sealing and protective function at the exposed right-hand electrode region that the left-hand first seal 64 performs for limitation [1.4].

115. Thus, in my opinion, the right-hand first seal 64 in Figure 6 constitutes the claimed second edge protection material sealing the exposed portion of the inner surface of the first electrode layer. Gauthier therefore discloses limitation [1.5].

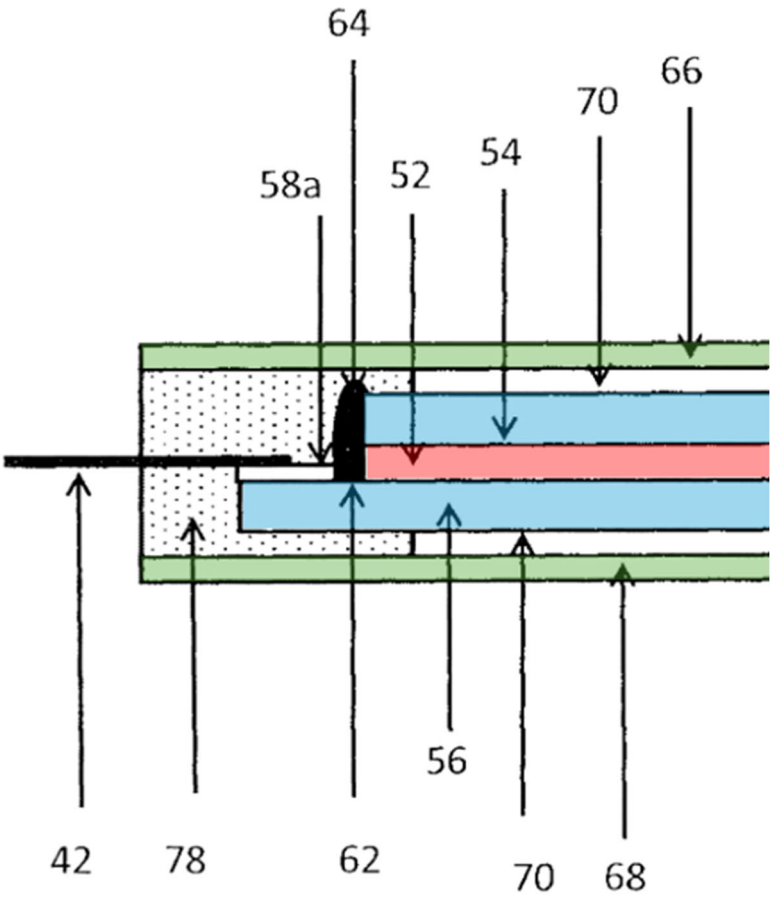
2. Claim 2: The electrochromic device of claim 1, wherein: the first edge protection material is in an L shape, further sealing a side surface of the first electrode layer and a portion of an external surface of the first electrode layer.

116. In my opinion, Gauthier discloses, or at least renders obvious, the L-shaped first edge protection material recited in claim 2.

117. As I explained for limitation [1.4], the left-hand first seal 64 shown in Figure 6 corresponds to the claimed first edge protection material. Seal 64 is positioned at the offset cut region, adjacent to the cut edge of switching material 52,

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and contacts the conductive coating of the uncut substrate/electrode structure 56. (EX1004, 10:51-64.) Figure 6 further shows first seal 64 extending along the side of the cut switching material 52 and the cut substrate/electrode structure 54 and extending onto at least a portion of the top or upper surface of substrate/electrode structure 54, giving the seal 64 a slight L-shape profile.



EX1004, Figure 6 (annotated).

118. A person of ordinary skill in the art would have understood the L-shaped profile of seal 64 to further seal the side surface of the cut portion of

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substrate/electrode structure 54 and a portion of the top or upper external surface of that same substrate/electrode structure 54. This configuration is consistent with Gauthier's express teaching that seal material may be selected "to provide good adhesion to contacted surfaces," including a "substrate," "conductive layer," "electrode," "switching material," and electrical connectors. (EX1004, 16:64-17:3.) In my opinion, extending seal 64 up the side of the cut portion of substrate/electrode structure 54 and onto the top/upper surface of substrate/electrode structure 54 would increase the surface area contacted by the seal and improve retention of the seal at the cut edge. Gauthier expressly recognizes the benefit of increased adhesion area. Gauthier explains that offsetting the substrate and conductive layer may provide "a larger surface area for the first, second or first and second sealing material to adhere to." (EX1004, 6:61-67.) Gauthier contrasts that arrangement with a configuration without an offset, where adhesion would depend on the through-cut edge of the film, which provides "a substantially reduced surface area." (EX1004, 6:67-7:3.) A person of ordinary skill in the art would have understood from this teaching that extending seal material onto adjacent side and top/external surfaces of the substrate/electrode structure would be a predictable way to increase seal contact area and improve seal adhesion and retention.

119. A person of ordinary skill in the art also would have understood that the portion of seal 64 extending onto the top or upper surface of substrate/electrode

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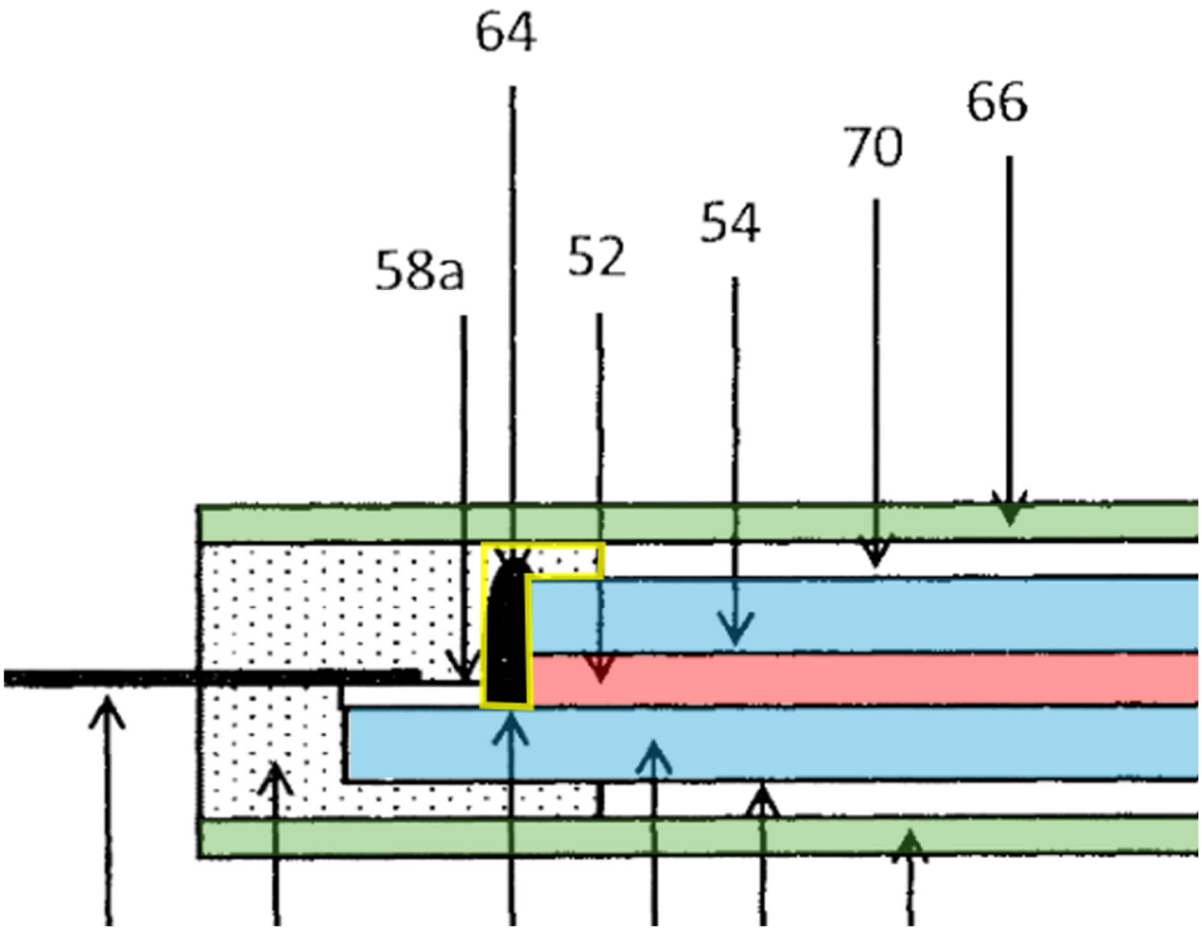
structure 54 could be longer, shorter, or otherwise adjusted depending on ordinary design considerations, including the seal material, the substrate/electrode material, the thickness of the film stack, and the desired barrier or adhesion performance. In my opinion, such dimensional adjustment of an edge seal would have been routine and predictable.

120. Alternatively, in my opinion, it would have been obvious to combine Gauthier's first seal 64 with a portion of Gauthier's second seal 78 to provide the claimed L-shaped first edge protection material. Gauthier teaches that "[t]he second seal may be a separate application of the same material as the first seal, or may be a different seal." (EX1004, 12:6-9.) As illustrated in Figure 6, second seal 78 encapsulates the switching film and the first seals 64. Gauthier explains that second seal 78 is disposed in a space defined in part by transparent layers 66 and 68 and first seal 64, thereby "encapsulating the first seal, busbar and electrical connector," while first seal 64 prevents second seal 78 from contacting the switching material. (EX1004, 10:64-11:2.)

121. A portion of second seal 78 is positioned on top of substrate/electrode structure 54 adjacent first seal 64, between the top transparent layer 66 and the top surface of substrate/electrode structure 54. A person of ordinary skill in the art would have understood that first seal 64 and the adjacent portion of second seal 78 together form a sealing structure extending along the side of the cut edge region and over a

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portion of the top or external surface of substrate/electrode structure 54. In my opinion, combining first seal 64 with that adjacent portion of second seal 78, or modifying first seal 64 itself to extend farther onto the top surface, would have been an obvious and predictable way to improve adhesion to and protection of the substrate/electrode structure at the cut edge.



EX1004, Figure 6 (annotated).

122. This modification would have been especially straightforward where the same seal material is used for both the first and second seals. Gauthier expressly permits the second seal to be "a separate application of the same material as the first

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seal." (EX1004, 12:6-9.) In that circumstance, a person of ordinary skill in the art would have understood the first seal and adjacent portion of the second seal as compatible sealing materials that could be applied or dimensioned to provide a continuous or cooperating L-shaped edge protection structure.

123. This understanding is consistent with the stated purpose of the '870 patent's edge protection. The '870 patent does not identify a unique technical benefit for an "L shape" apart from further sealing the edge structure. Rather, the '870 patent describes edge protection generally as protecting the electrochromic film from undesired materials, oxygen, and moisture. (EX1001, 1:60-64, 7:61-67.) Gauthier's modified first seal, or the combination of first seal 64 and an adjacent portion of second seal 78, serves the same protective purpose. Gauthier teaches using seal material to isolate switching material from the ambient environment, including air and moisture, and selecting seal materials for adhesion and barrier properties, including gas impermeability and water/moisture resistance or water/moisture impermeability. (EX1004, 6:41-55, 16:64-17:16.)

124. Accordingly, in my opinion, Gauthier discloses or at least renders obvious the subject matter of claim 2. Gauthier's left-hand first seal 64, either by itself or in combination with the adjacent portion of second seal 78, provides an L-shaped edge protection material that further seals a side surface of the first electrode layer and a portion of an external surface of the first electrode layer.

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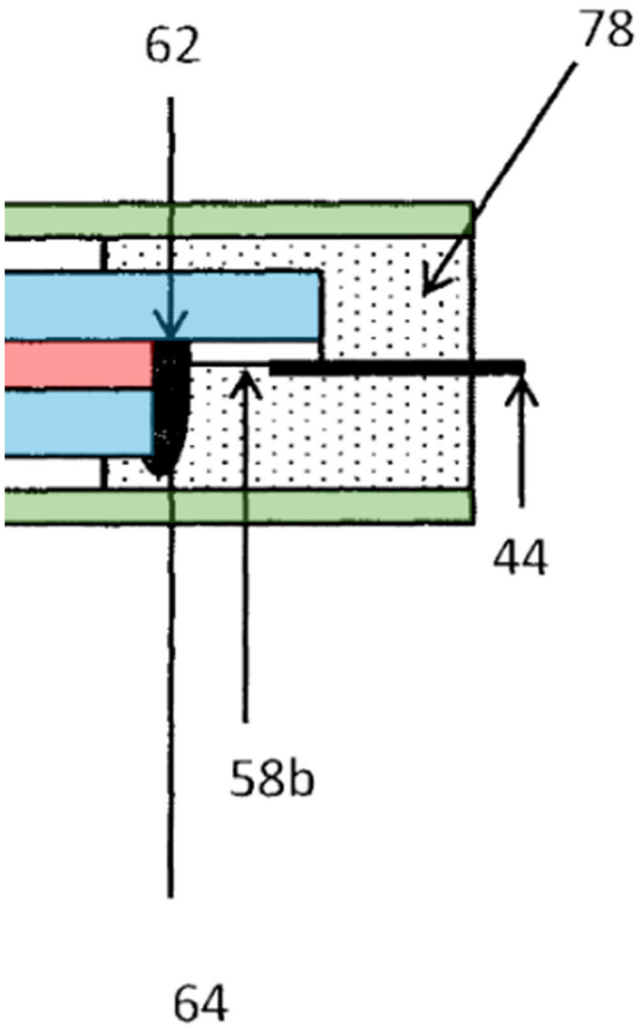
3. Claim 3: The electrochromic device of claim 1, wherein: the second edge protection material is in an L shape, further sealing a side surface of the second electrode layer and a portion of an external surface of the second electrode layer.

125. In my opinion, Gauthier discloses, or at least renders obvious, the L-shaped second edge protection material recited in claim 3 for the same reasons I discussed above for claim 2.

126. Figure 6 of Gauthier provides two corresponding offset cut regions and two corresponding first seals 64. As I explained for limitation [1.5], the right-hand first seal 64 corresponds to the claimed second edge protection material. That right-hand first seal 64 is applied at the offset edge where the second substrate/electrode structure 56 is cut back to expose the conductive coating on the first substrate/electrode structure 54. (EX1004, 10:54-64.)

127. As with the left-hand seal discussed for claim 2, the right-hand seal structure extends along the cut portions of the switching material and the second substrate/electrode edge region, and continues over a portion of the external surface of the second substrate/electrode structure 56. In my opinion, a person of ordinary skill in the art would have understood this configuration to provide an L-shaped sealing profile at the right-hand offset edge. Seal 64 therefore seals both the side surface of the cut-back substrate/electrode structure 56 and a portion of its external surface.

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EX1004, Figure 6 (annotated).

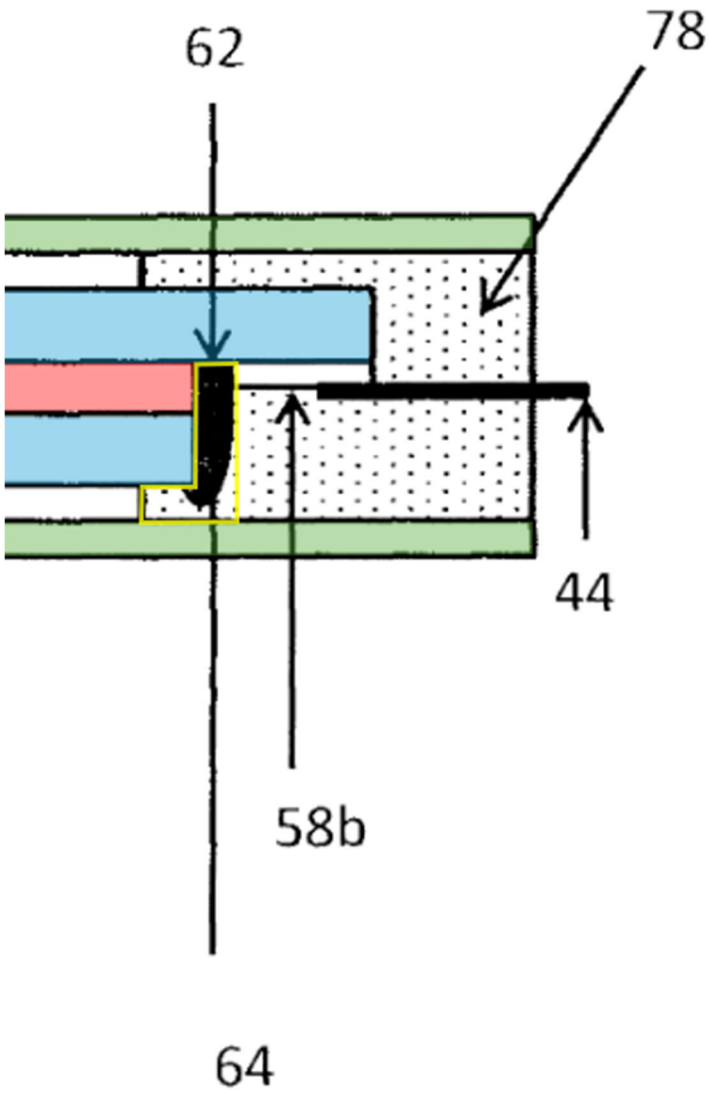
128. Gauthier's teachings regarding seal materials support this understanding. Gauthier teaches that seal materials may adhere to substrates, conductive layers, electrodes, and switching material, and may provide barrier properties including gas impermeability and water/moisture resistance or water/moisture impermeability. (EX1004, 16:64-17:16.) As I explained for claim 2, a person of ordinary skill in the art would have recognized that extending the seal

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onto an external surface of the substrate/electrode structure would increase the contacted surface area and improve adhesion and retention of the seal at the cut edge. A person of ordinary skill also would have understood that the portion of the seal extending onto the external surface of substrate/electrode structure 56 could be longer, shorter, or otherwise adjusted depending on ordinary design considerations, including the seal material, substrate/electrode materials, device dimensions, and desired sealing performance.

129. Alternatively, and for the same reasons I explained for claim 2, it would have been obvious to combine the right-hand first seal 64 with a portion of Gauthier's second seal 78, or to simply modify and extend first seal 64, to improve adhesion to and protection of the second substrate/electrode structure 56. Gauthier teaches that "[t]he second seal may be a separate application of the same material as the first seal, or may be a different seal." (EX1004, 12:6-9.) Gauthier also teaches that second seal 78 encapsulates the first seal, busbar, and electrical connector in the Figure 6 structure. (EX1004, 10:64-11:2.) In my opinion, a person of ordinary skill in the art would have understood that the adjacent portion of second seal 78 could cooperate with first seal 64, or that first seal 64 could be extended, to form an L-shaped edge protection material at the right-hand offset edge.

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EX1004, Figure 6 (annotated).

130. Thus, in my opinion, Gauthier's right-hand first seal 64, either by itself or in combination with an adjacent portion of second seal 78, discloses or at least renders obvious an L-shaped second edge protection material that further seals a side surface of the second electrode layer and a portion of an external surface of the second electrode layer. Accordingly, Gauthier discloses or at least renders obvious the subject matter of claim 3.

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4. Claim 4: The electrochromic device of claim 1, wherein: the first edge protection material and the second edge protection material comprise epoxy.

131. In my opinion, Gauthier discloses the first and second edge protection materials comprising epoxy.

132. As I explained for limitations [1.4] and [1.5], the left- and right-hand first seals 64 in Gauthier Figure 6 correspond to the claimed first and second edge protection materials. Gauthier teaches that suitable seal materials may include "a thermoplastic, a thermoset, a rubber, a polymer or metal, a metallized tape, or combinations thereof." (EX1004, 16:63-65.) Gauthier then identifies "epoxy groups" among exemplary functional groups for thermoset seal materials. (EX1004, 17:17-24.)

133. Gauthier also expressly identifies epoxy seal materials as exemplary seal materials. For example, Gauthier identifies DP100, DP105, DP110, and DP125 from 3M as suitable seal materials. (EX1004, 18:1-3, 19:5-31.) A person of ordinary skill in the art would have understood those identified materials to be epoxy-based seal materials. In my opinion, Gauthier therefore clearly teaches that its first seals 64 can comprise epoxy.

134. Because Figure 6 includes corresponding left- and right-hand first seals 64 at the opposing offset edge regions, a person of ordinary skill in the art would have understood that the same epoxy-based seal material could be used for both the

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first and second edge protection materials. Using the same epoxy material on both sides would have been straightforward and consistent with Gauthier's disclosure of applying corresponding seals at the two exposed edge regions. Accordingly, in my opinion, Gauthier discloses the subject matter of claim 4.

5. Claim 5: The electrochromic device of claim 1, wherein the first edge protection material and the second edge protection material comprise electrically conductive material.

135. In my opinion, Gauthier discloses first and second edge protection materials that comprise electrically conductive material.

136. First, Gauthier expressly contemplates electrical conductivity in the first seal 64 itself. Gauthier states that, "[i]n some aspects, the first seal has low amount of electrical conductivity." (EX1004, 3:49-51.) In my opinion, a person of ordinary skill in the art would have understood this disclosure to mean that Gauthier's first seal may include some electrically conductive character. The phrase "low amount" is also technically significant. A person of ordinary skill would have understood that, in an electrochromic device having opposed electrode structures, any conductivity in an edge seal must be implemented in a controlled manner so that the seal does not create an unintended short between the opposed electrodes.

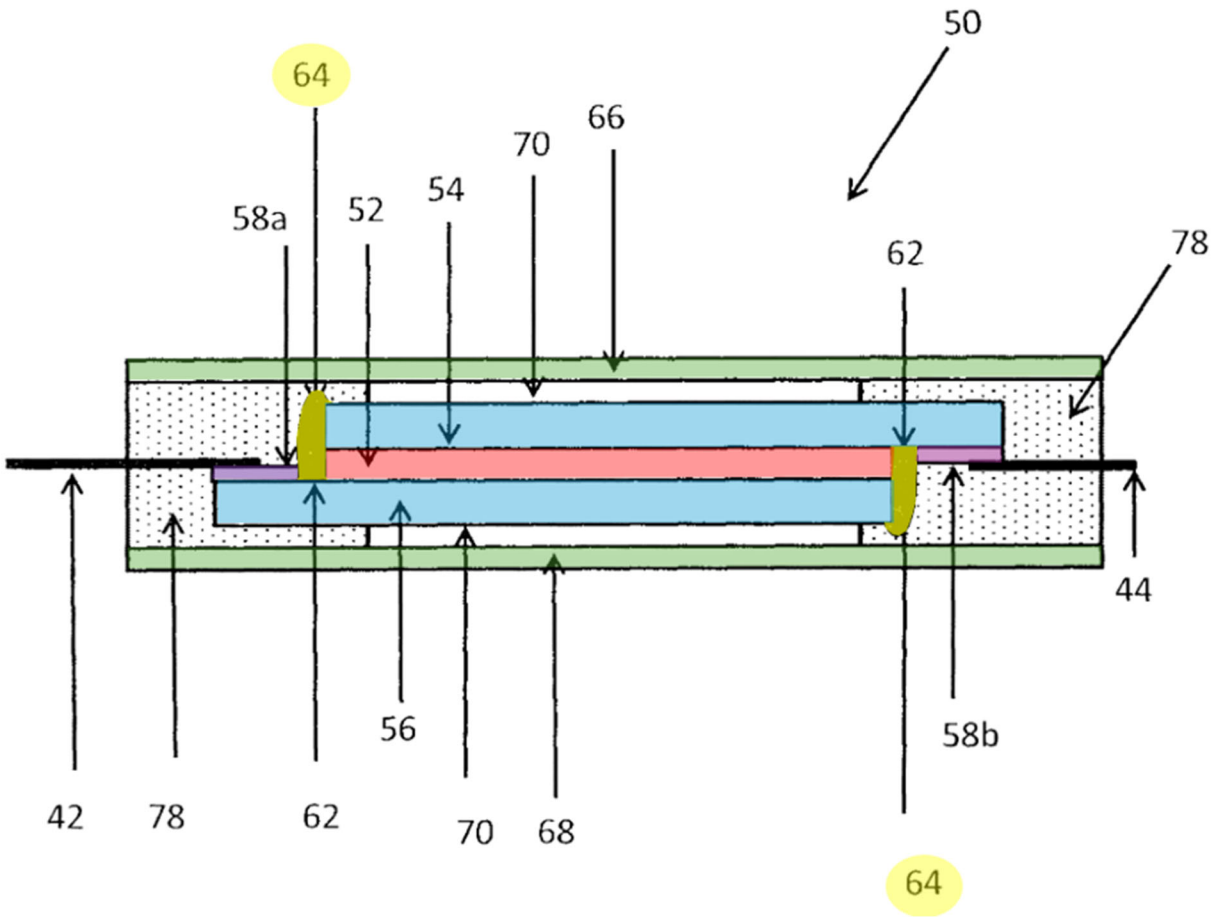
137. Second, Gauthier teaches that its seals 64 may comprise "metal" or "a metallized tape," or combinations thereof, and also teaches that seal materials may be selected for adhesion and barrier properties. (EX1004, 16:63-17:16.) Gauthier

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further teaches that "[a] seal overlaid with a metal layer or metal foil or tape may be a useful edge seal system." (EX1004, 18:65-19:1.) A person of ordinary skill in the art would have understood metal, metal foil, metal tape, metallized tape, and a metal layer to be electrically conductive materials. Thus, Gauthier discloses seal structures that include electrically conductive material.

138. Gauthier's disclosure is particularly relevant because its first seals 64 are located adjacent to the busbars and exposed conductive coatings of the electrode surfaces. In Figure 6, first seal 64 is applied in space 62 between the busbar 58a/58b and switching material 52, adjacent to the cut edge of the switching material, while the busbars contact the conductive coatings of the substrate/electrode structures 54 and 56 exposed by the offset cuts. (EX1004, 10:54-64.) In the annotated version of Figure 6 below, first seal 64 is shown in yellow, substrates/electrode structures 54 and 56 are shown in blue, switching material 52 is shown in red, and busbars 58a and 58b are shown in purple.

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EX1004, Figure 6 (annotated).

139. A person of ordinary skill in the art would have understood Gauthier's metal-overlay teaching to be implementable as a conductive portion of the edge seal system. For example, a metal layer, metal foil, metal tape, or metallized tape could provide localized conductivity, electrical connection, or shielding in the busbar/edge region without requiring the entire seal body to be uniformly conductive. In my opinion, that is consistent with Gauthier's statement that the first seal may have a "low amount of electrical conductivity." (EX1004, 3:49-51.) It is also consistent

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with the need in electrochromic devices to avoid an unintended conductive path that would short opposed electrode structures.

140. Claim 5 recites edge protection materials that "comprise" electrically conductive material. From a technical perspective, a person of ordinary skill in the art would understand that language to require the edge protection materials to *include* electrically conductive material, not consist entirely or uniformly of electrically conductive material. This distinction matters because an electrochromic device includes opposed electrode structures that must remain electrically separated except through the intended electrochromic stack or intended electrical connections. If edge protection material were electrically conductive across the entire sealed edge region in a way that connected the opposed anode-side and cathode-side structures, the device would be shorted and would not perform normal electrochromic switching.

141. The '870 patent's Figure 9 illustrates this technical issue. The '870 patent describes Figure 9 as including electrochromic-film sides 901a and 901b, "one as an anode and the other as a cathode," with the edges covered by edge protection material, such as epoxy 905 and 915. (EX1001, 8:57-65.) In the annotated version of Figure 9 below, substrates 902 and 904 are shown in green, electrochromic-film sides 901a and 901b are shown in blue, and edge protection materials 905 and 915 are shown in yellow.

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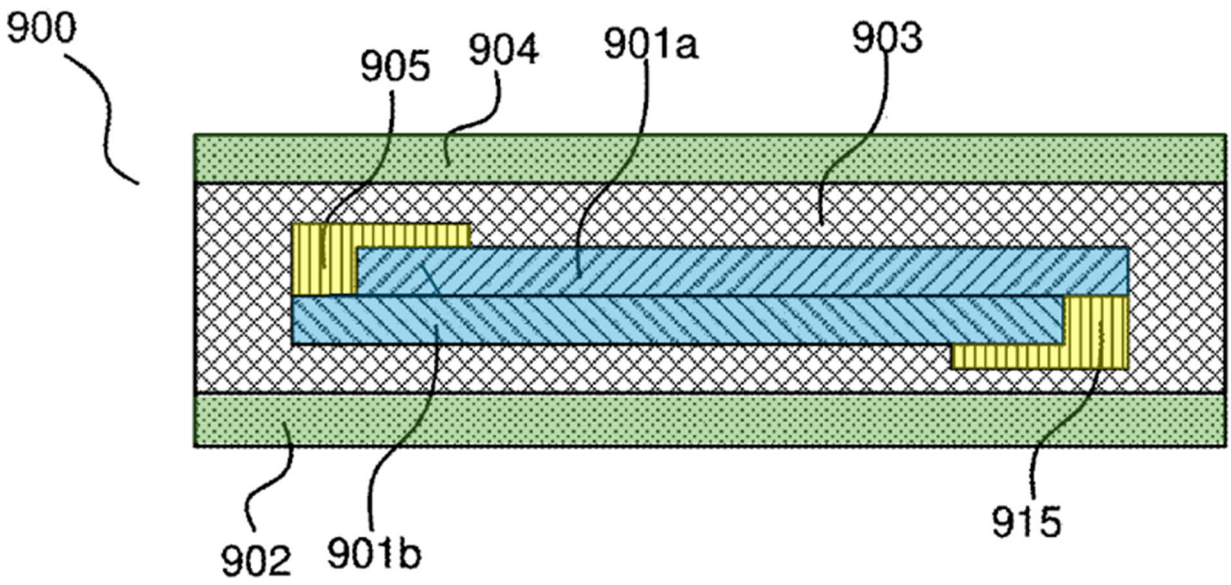


FIG. 9

EX1001, Figure 9 (annotated).

142. In my opinion, if the yellow edge protection materials 905 and 915 in Figure 9 were made electrically conductive across the entire edge regions in a manner that electrically connected the blue anode-side and cathode-side structures, they would short the device and prevent normal electrochromic switching. The ’870 patent states only that, “[i]n some embodiments,” the edge protection material “may be electrically conductive so that it can function as the electrodes” or, alternatively, “can conduct current to the electrode layer and/or charge storage layer.” (EX1001, 8:11-16.) The ’870 patent does not explain how the claimed first and second edge protection materials could be completely electrically conductive across the claimed

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edge-sealing arrangement without shorting the opposed electrode structures. (EX1001, 8:11-16.)

143. For those reasons, a person of ordinary skill in the art would have understood claim 5's "comprise electrically conductive material" language to be satisfied by an edge protection material that includes electrically conductive material in a controlled or localized manner, rather than requiring a seal that is conductive throughout its *entire* volume or across the *entire* edge-sealing region. Gauthier discloses that type of edge seal. Gauthier teaches first seals 64 at both opposing offset edge regions, teaches that the first seal may have a "low amount of electrical conductivity," and teaches metal-containing or metal-overlaid seal structures. (EX1004, 3:49-51, 16:63-17:16, 18:65-19:1.)

144. Accordingly, in my opinion, Gauthier discloses first and second edge protection materials comprising electrically conductive material as recited in claim 5. Gauthier's left- and right-hand first seals 64 correspond to the claimed first and second edge protection materials, and Gauthier teaches that such seals may include electrically conductive material, including through low conductivity, metal, metallized tape, metal layer, metal foil, or tape.

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6. Claim 6: The electrochromic device of claim 1, wherein: the first edge protection material and the second edge protection material are cured with heat or ultraviolet light, functioning as oxygen and moisture blockers.

145. I understand that claim 6 depends from claim 1 and further recites that "the first edge protection material and the second edge protection material are cured with heat or ultraviolet light, functioning as oxygen and moisture blockers." I understand that the recitation that the edge protection materials "are cured with heat or ultraviolet light" is product-by-process language. I further understand that, for purposes of patentability, a product-by-process limitation is not to be entitled to patentable weight unless the process imparts a structural or functional difference to the claimed product.

146. From a technical perspective, claim 6 does not recite any particular chemical structure, crosslink density, composition, permeability value, cure depth, or other structural property resulting from heat-curing or ultraviolet-light curing. Instead, claim 6 recites alternative curing mechanisms for forming edge protection materials that function as oxygen and moisture blockers. In my opinion, a person of ordinary skill in the art would not understand the claim language itself to require a specific structural distinction between a heat-cured edge protection material and a UV-cured edge protection material. Rather, the relevant technical features are the cured seal material and its barrier function.

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147. Regardless, to the extent claim 6 is treated as limiting, in my opinion Gauthier discloses this limitation. As I explained for limitations [1.4] and [1.5], Gauthier's left- and right-hand first seals 64 correspond to the claimed first and second edge protection materials. Gauthier teaches that the first seal may comprise thermoplastic and/or thermosetting polymers, that "the first seal is a thermoset material," and that the first seal may be selected so that it "does not release water when curing." (EX1004, 4:59-63.)

148. Gauthier further teaches that thermoset seal materials may include polymers with reactive groups, and that "[c]uring or hardening of such materials may be chemical, radiation, temperature or moisture dependent." (EX1004, 17:17-27.) Gauthier expressly identifies the same curing mechanisms recited in claim 6. Gauthier states that "radiation curing may include exposure to light (UV light or visible light)," and that "temperature curing may include resting the material at an elevated temperature." (EX1004, 17:25-30.) Gauthier also teaches that a chemical cure may be heated to accelerate curing. (EX1004, 17:30-35.) A person of ordinary skill in the art would have understood these disclosures to teach heat-curable and UV-curable seal materials suitable for Gauthier's first seals 64.

149. Gauthier likewise teaches that the cured seals function as oxygen and moisture blockers. Gauthier explains that a seal for a switchable film prevents ingress of matter that may affect performance of the switching material, and that seal

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materials may be selected to maintain isolation of the switching material. (EX1004, 6:41-55, 16:64-17:10.) Gauthier further teaches that a seal "may be gas-impermeable" and "may be resistant to water, or may be water impermeable." (EX1004, 17:7-10.) In my opinion, a person of ordinary skill in the art would have understood gas-impermeability to include blocking oxygen ingress, and water/moisture resistance or water/moisture impermeability to include blocking moisture ingress. These teachings correspond to claim 6's recitation that the edge protection materials function as oxygen and moisture blockers.

150. Thus, even if the "cured with heat or ultraviolet light" language is given patentable weight, it is my opinion that Gauthier discloses using heat- or UV-curable thermoset seal materials for the first and second edge protection materials, and further discloses cured barrier seals that block oxygen and moisture as recited in claim 6.

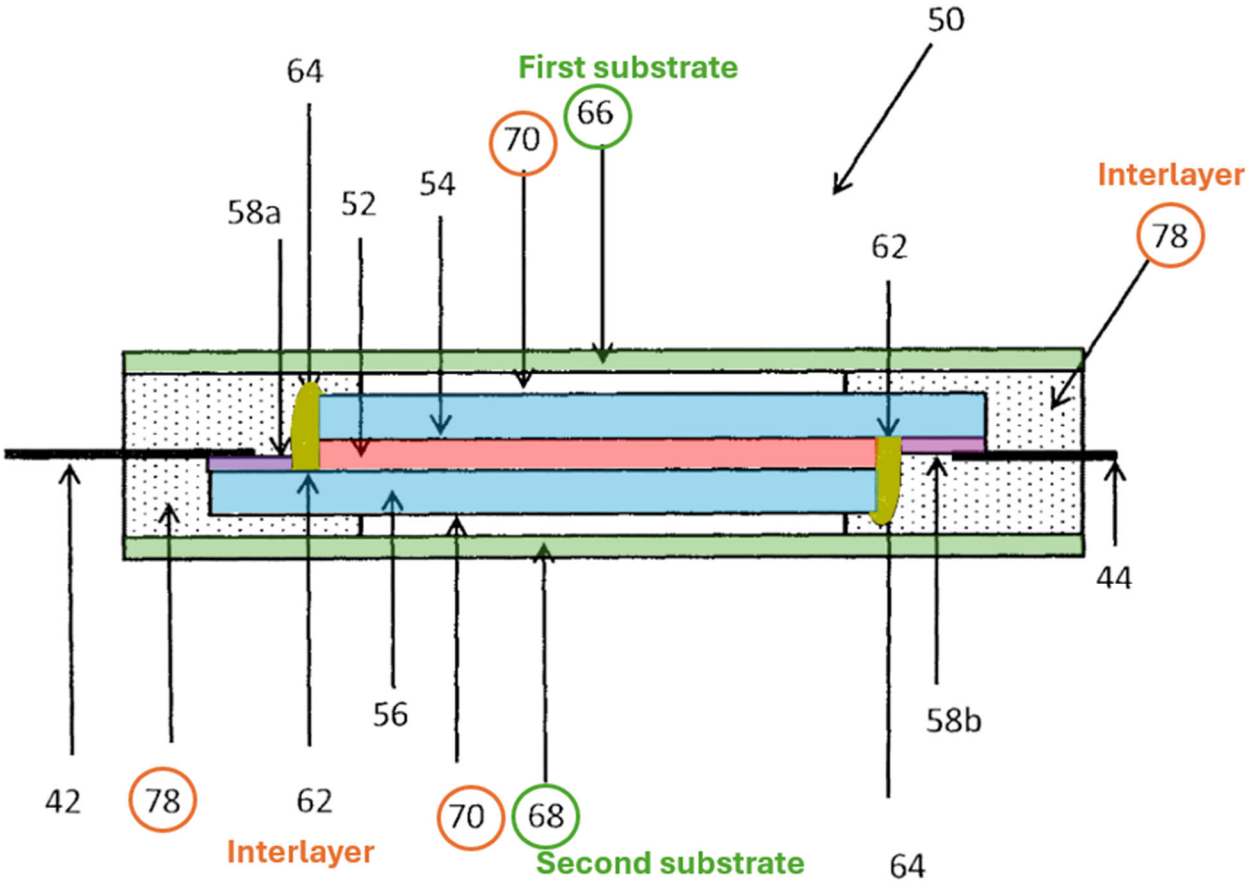
7. Claim 7

a) [7.1] The electrochromic device of claim 1, further comprising: a first substrate; a second substrate; and an interlayer between the first substrate and the second substrate,

151. In my opinion, Gauthier discloses a first substrate, a second substrate, and an interlayer between the first and second substrates. Figure 6 shows the sealed switchable/electrochromic film positioned between first and second transparent layers 66 and 68, such as glass. In the annotated Figure 6 below, transparent layers

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66 and 68 are shown in green and correspond to the claimed first and second substrates.



EX1004, Figure 6 (annotated).

152. Gauthier explains that second seal 78 may be disposed in a space defined in part by "the first and second transparent layers 66, 68 and first seal 64," thereby "encapsulating the first seal, busbar and electrical connector." (EX1004, 10:64-11:2.) Gauthier further explains that transparent layers 66 and 68 "may be affixed to substrates 54, 56 by an adhesive 70." (EX1004, 11:2-5.) In my opinion, a person of ordinary skill in the art would have understood transparent layers 66 and

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68 to correspond to the claimed first and second substrates, and the material region between them, including adhesive 70 and second seal 78, to correspond to the claimed interlayer.

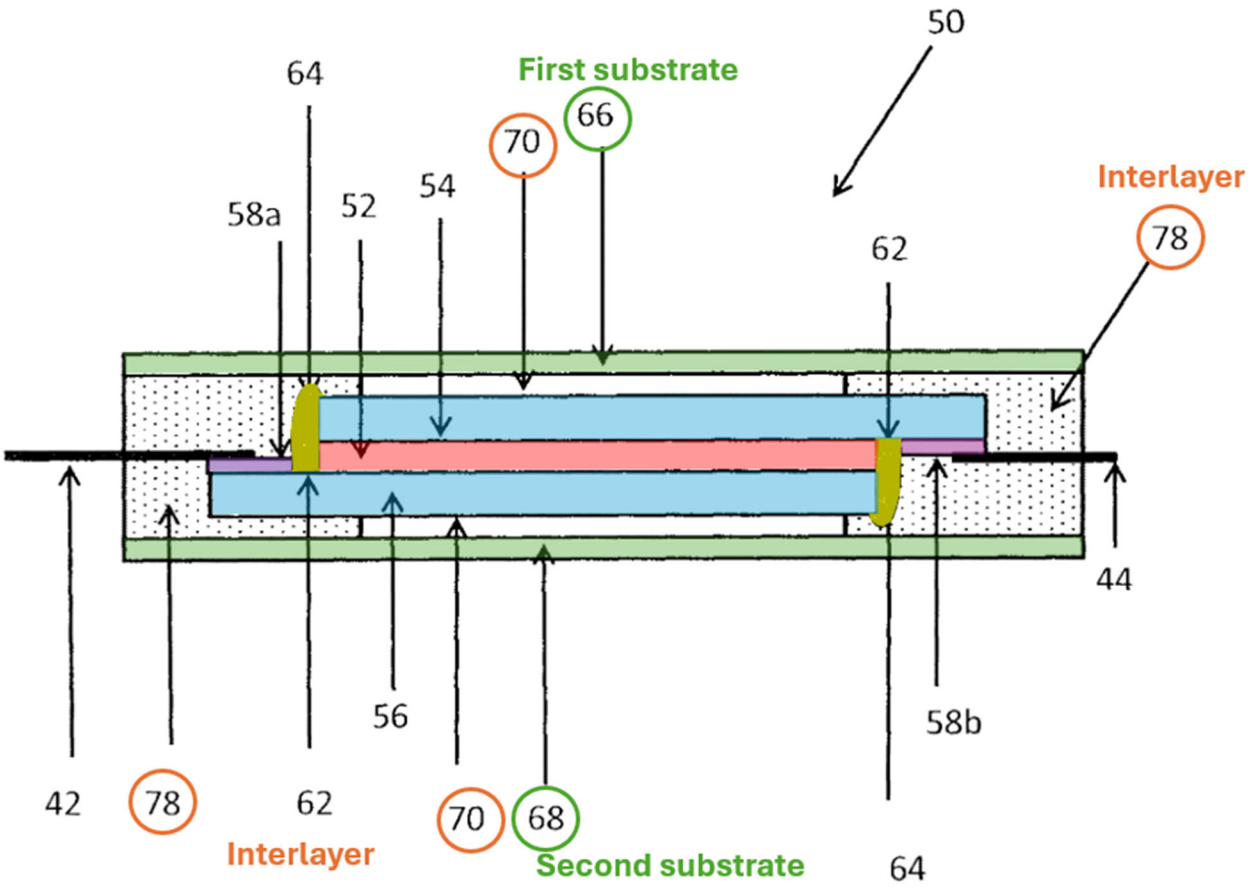
153. Gauthier confirms that this structure is used in a laminated assembly. Gauthier teaches that "[a] switchable film may be further laminated with heat and pressure between layers of glass, to provide a switchable, laminated glazing," and that "[t]he switchable film may be layered between layers of PVB, and this between first and second layers of glass." (EX1004, 16:25-33.) Gauthier further describes processing a "glass-PVB-switchable film-PVB-glass sandwich" using heat and pressure. (EX1004, 16:33-41.) A person of ordinary skill in the art would have understood these disclosures to teach an interlayer between first and second substrates that encapsulates or contains the switchable/electrochromic film structure.

b) [7.2] wherein: the first electrode layer, the second electrode layer, the first edge protection material, and the second edge protection material are laminated within the interlayer.

154. In my opinion, Gauthier discloses that the first electrode layer, second electrode layer, first edge protection material, and second edge protection material are laminated within the interlayer. As explained for claim 1, Gauthier includes first and second substrate/electrode structures 54 and 56, and Gauthier's left- and right-hand first seals 64 correspond to the claimed first and second edge protection materials. As illustrated in annotated Figure 6 below, the first electrode layer, second

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electrode layer, and first and second edge protection materials are positioned between transparent substrate layers 66 and 68 within the region occupied by second seal 78 and adhesive 70. (EX1004, 10:54-11:5.)



EX1004, Figure 6 (annotated).

155. Gauthier explains that second seal 78 occupies the edge or perimeter space between transparent layers 66 and 68 and encapsulates first seals 64, busbars 58a and 58b, and a portion of the electrical connector. (EX1004, 10:64-11:2.) Thus, at the edge regions, Gauthier's second seal 78 surrounds and encapsulates the claimed first and second edge protection materials. In the central region, adhesive

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70 affixes transparent layers 66 and 68 to substrate/electrode structures 54 and 56. (EX1004, 11:2-5.) A person of ordinary skill in the art would have understood this arrangement to place the electrode layers and edge protection materials within the interlayer between the first and second transparent substrates 66 and 68.

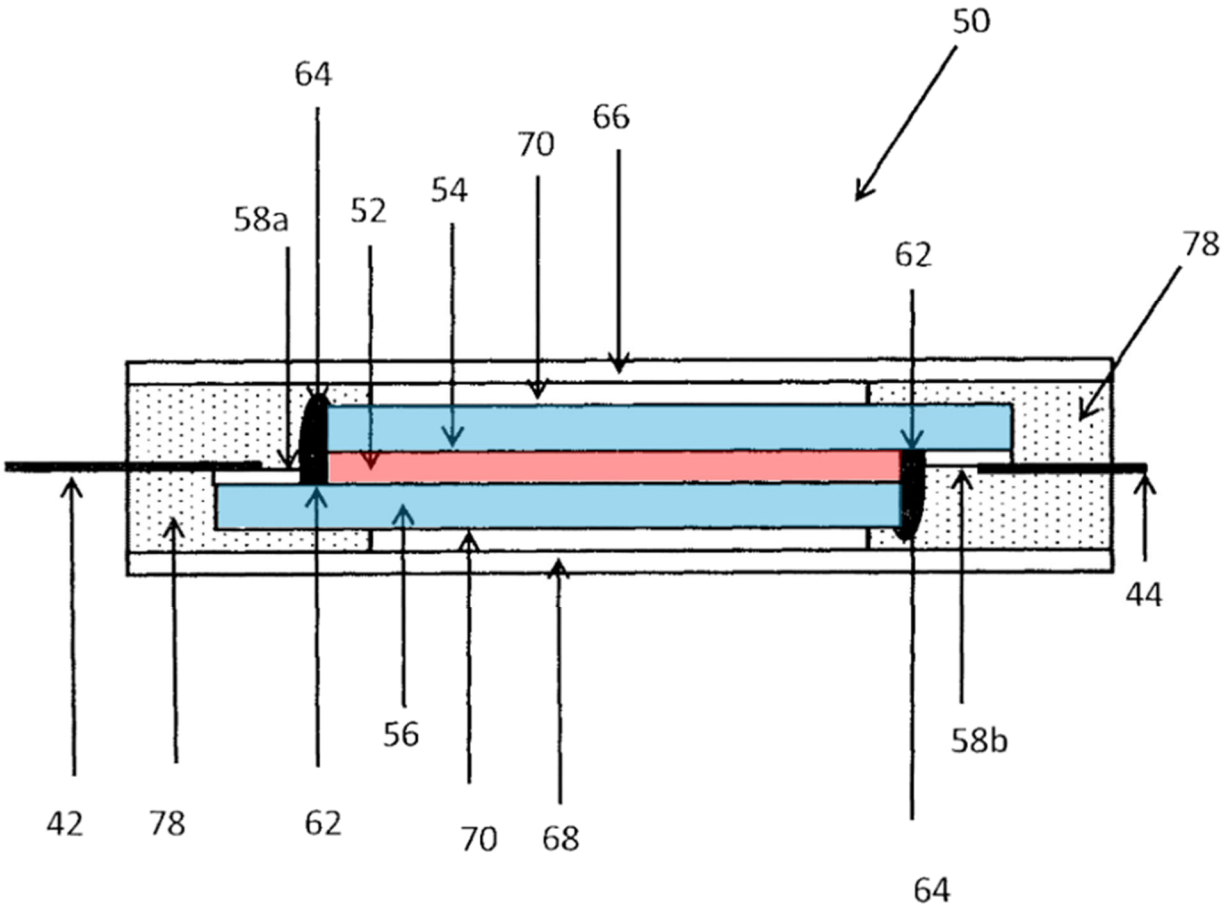
156. This understanding is further supported by Gauthier's broader lamination disclosure. Gauthier teaches laminating the switchable film between PVB layers and outer glass layers in a "glass-PVB-switchable film-PVB-glass sandwich." (EX1004, 16:25-41.) Because Gauthier's switchable film includes the electrode layers and first seals discussed for claim 1, laminating that film within the PVB/glass stack places those electrode layers and edge protection materials within the interlayer between the outer substrates. In my opinion, Gauthier therefore discloses all elements of claim 7.

8. Claim 8: The electrochromic device of claim 1, wherein the first electrode layer and the second electrode layer sandwich a layer of electrochromic material, a layer of electrolyte material, and a layer of charge storage material.

157. I understand that claim 8 depends from claim 1 and further recites that "the first electrode layer and the second electrode layer sandwich a layer of electrochromic material, a layer of electrolyte material, and a layer of charge storage material." In my opinion, Gauthier discloses, or at least renders obvious, the elements of claim 8.

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158. As I explained for limitation [1.1], Gauthier teaches first and second substrate/electrode structures 54 and 56, with switching material 52 positioned between the first and second electrode layers. (EX1004, 10:54-59.) Thus, Gauthier's first and second electrode layers sandwich the active electrochromic switching material. In the annotated Figure 6 below, substrate/electrode structures 54 and 56 are shown in blue, and switching material 52 is shown in red.



EX1004, Figure 6 (annotated).

159. Gauthier further teaches that the sandwiched switching material may include electrochromic material, electrolyte material, and charge-storage or counter-

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electrode functionality. Gauthier explains that the active layer may be an "electrochromic active layer" responsive to electricity. (EX1004, 19:64-20:8.) Gauthier further explains that electrochromic active layers may comprise compounds that behave as a redox pair: when electricity is applied, one compound is electrochemically oxidized from a colorless state to a colored state, and another compound is electrochemically reduced from a colorless state to a colored state. (EX1004, 20:14-29.) A person of ordinary skill in the art would have understood the electrochemically color-changing compound to correspond to electrochromic material, and the complementary redox/charge-balancing compound to provide charge-storage or counter-electrode functionality in the electrochromic system.

160. Gauthier also teaches electrolyte material within the sandwiched switching material. Gauthier states that the switching material may comprise a polymer and switchable compound, and may optionally include a "supporting electrolyte." (EX1004, 20:43-49.) Gauthier further explains that components of the switching material, including a supporting electrolyte and charge carrier, may provide secondary functions, and that a polymer comprising a switching compound may provide multiple functionalities, including "a charge carrier function" and/or "a supporting electrolyte function." (EX1004, 20:61-21:5.) Gauthier identifies exemplary supporting electrolytes, including tetrabutylammonium tetrafluoroborate and tetrabutylammonium bis((trifluoromethyl)sulfonyl)imide (TBATFSI).

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(EX1004, 21:18-20.) In my opinion, a person of ordinary skill in the art would have understood these disclosures as teaching electrolyte material for supporting ion or charge transport during electrochromic switching.

161. Gauthier also teaches that the switching material may be arranged in one or more layers. Gauthier states that the switching material may be "a single layer of material" or "two or more layers, cast or extruded sequentially or simultaneously one on top of the other." (EX1004, 20:49-52.) Gauthier further teaches embodiments in which two or more layers of switching material are co-extruded, or a first layer is applied to a first substrate, a second layer is applied to a second substrate, and the resulting substrate-switching material-substrate sandwich is laminated. (EX1004, 22:23-45.) In my opinion, these disclosures would have taught a person of ordinary skill in the art that Gauthier's sandwiched switching material could be implemented as multiple functional layers between the opposing electrode layers.

162. In view of Gauthier's electrochromic redox-pair teachings, supporting-electrolyte teachings, charge-carrier teachings, and express disclosure of single-layer or multi-layer switching material, a person of ordinary skill in the art would have understood Gauthier to disclose, or at least render obvious, implementing the sandwiched switching material as layered electrochromic, electrolyte, and charge-storage/counter-electrode materials between the opposing electrode layers.

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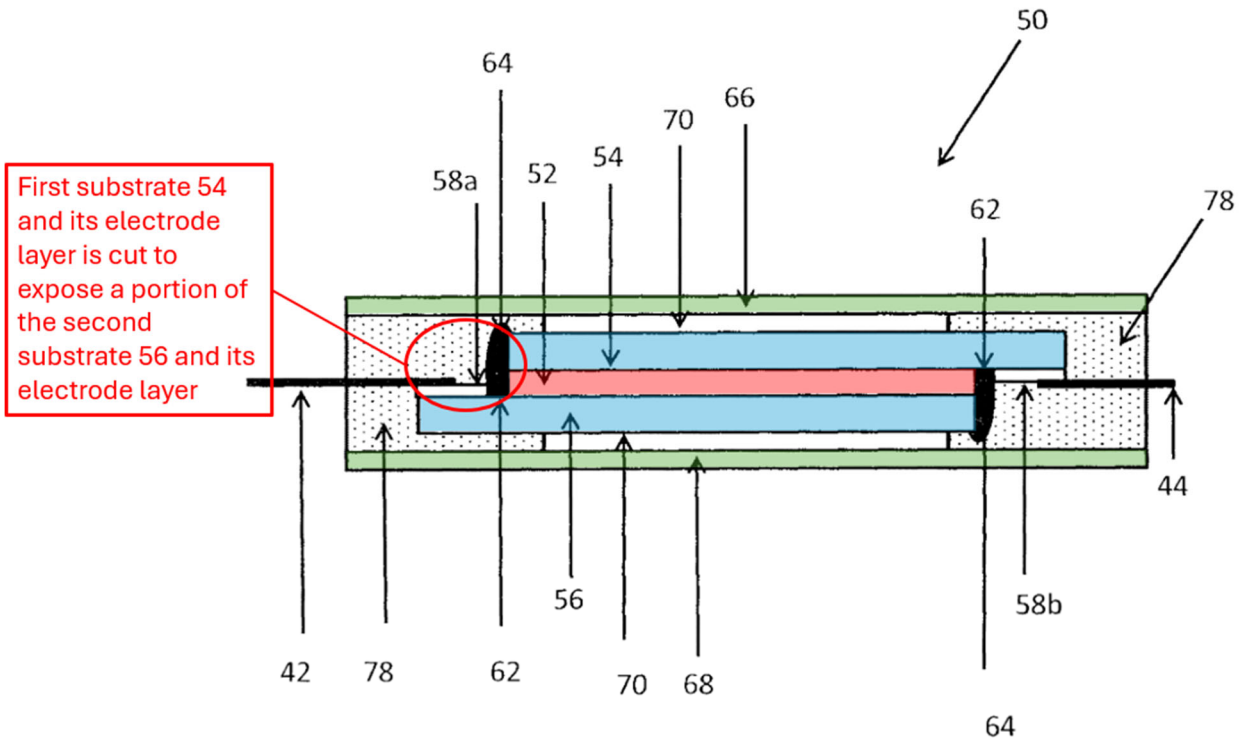
Accordingly, in my opinion, Gauthier discloses or at least renders obvious the subject matter of claim 8.

9. Claim 9: The electrochromic device of claim 8, wherein the layer of electrochromic material, the layer of electrolyte material, and the layer of charge storage material are cut in a same way as the edge of the first electrode layer to expose the portion of the inner surface of the second electrode layer.

163. I understand that claim 9 depends from claim 8 and further recites that "the layer of electrochromic material, the layer of electrolyte material, and the layer of charge storage material are cut in a same way as the edge of the first electrode layer to expose the portion of the inner surface of the second electrode layer." In my opinion, Gauthier discloses, or at least renders obvious, the elements of claim 9.

164. As I explained for claim 8, Gauthier's switching material 52 includes the claimed electrochromic material, electrolyte material, and charge-storage material between the first and second electrode layers. As I explained for limitation [1.2], Gauthier teaches cutting the edge of the first electrode layer to create the left-hand offset edge of Figure 6 and expose the conductive coating on substrate/electrode structure 56. Gauthier teaches that portions of substrate/electrode structures 54 and 56 are removed "to expose the conductive coating where the busbars may be applied," and that first seal 64 is then applied adjacent to "the cut edge of the switching material." (EX1004, 10:54-64.)

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EX1004, Figure 6 (annotated).

165. Gauthier's cutting process confirms that the active material layers are cut or removed in the same way as the edge of the first electrode layer to expose the second electrode layer. Gauthier teaches cutting the electrochromic film with a laser "to cut only through the upper most substrate and conductive coating, without cutting through or damaging the conductive coating of the lower substrate." (EX1004, 8:58-63.) Gauthier further explains that, after the electrochromic film is cut, "portions are removed, and any switching material remaining on the uncut substrate is removed." (EX1004, 9:32-41.) Gauthier similarly teaches that "cutting the first and second substrates to form offset edges, and removing a portion of the

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switching material provide a platform for mounting busbars ... directly on the transparent conductive layer on the interior side." (EX1004, 5:67-6:5.)

166. Thus, at the left-hand offset edge shown in the annotated figure, Gauthier cuts back the upper substrate/electrode structure 54 and removes the corresponding portion of switching material 52 in the same offset region, thereby exposing the inner conductive coating on substrate/electrode structure 56. Because Gauthier's switching material includes the electrochromic material, electrolyte material, and charge-storage material discussed for claim 8, a person of ordinary skill in the art would have understood those materials to be cut or removed with the same offset geometry as the edge of the first electrode layer to expose the second electrode layer.

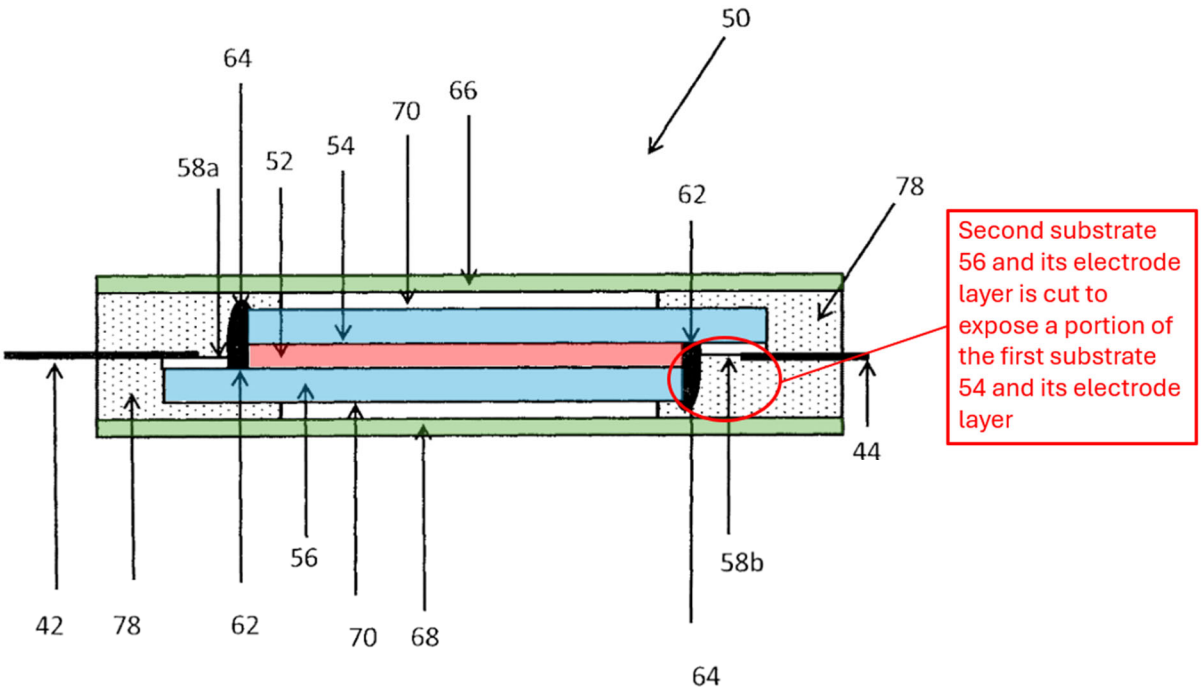
167. Accordingly, in my opinion, Gauthier discloses, or at least renders obvious, the subject matter of claim 9.

10. Claim 10: The electrochromic device of claim 8, wherein the layer of electrochromic material, the layer of electrolyte material, and the layer of charge storage material are cut in a same way as the edge of the second electrode layer to expose the portion of the inner surface of the first electrode layer.

168. In my opinion, Gauthier discloses, or at least renders obvious, the elements of claim 10 for the same reasons I discussed for claim 9, applied to the opposite, right-hand offset edge of Figure 6.

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169. As I explained for claim 8, Gauthier's switching material 52 includes the claimed electrochromic material, electrolyte material, and charge-storage material. And as I explained for limitation [1.3], the right-hand offset edge cuts back the second electrode layer, corresponding to the conductive coating on substrate/electrode structure 56, to expose the conductive coating on the first electrode layer, corresponding to the conductive coating on substrate/electrode structure 54. Gauthier teaches that portions of substrate/electrode structures 54 and 56 are removed "to expose the conductive coating where the busbars may be applied," and that first seal 64 is applied adjacent to "the cut edge of the switching material." (EX1004, 10:54-64.)



EX1004, Figure 6 (annotated).

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170. The same cutting process discussed for claim 9 applies at the opposing edge. Gauthier teaches cutting to form offset edges and removing switching material to provide a busbar platform "directly on the transparent conductive layer on the interior side." (EX1004, 5:67-6:5.) Gauthier also teaches that, after the electrochromic film is cut, "portions are removed, and any switching material remaining on the uncut substrate is removed." (EX1004, 9:32-41.) A person of ordinary skill in the art would have understood that these cutting and removal steps are used at the opposing offset edge to expose the corresponding inner conductive electrode surface.

171. Thus, at the right-hand side of Figure 6, the electrochromic material, electrolyte material, and charge-storage material of switching material 52 are cut or removed in the same offset geometry as the edge of the second electrode layer, exposing the inner surface of the first electrode layer. Accordingly, in my opinion, Gauthier discloses, or at least renders obvious, the subject matter of claim 10.

11. Claim 11: The electrochromic device of claim 1, wherein the first electrode layer comprises a first electrode layer including tin doped indium oxide (ITO).

172. I understand that claim 11 depends from claim 1 and further recites that "the first electrode layer comprises a first electrode layer including tin doped indium oxide (ITO)." In my opinion, Gauthier discloses a first electrode layer that includes tin doped indium oxide.

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173. As I explained for limitation [1.1], Gauthier discloses the claimed first electrode layer through the conductive coating on substrate/electrode structure 54. Gauthier expressly teaches that the conductive coating on the substrate/electrode structure may include indium tin oxide, which a person of ordinary skill in the art would understand to be tin-doped indium oxide, commonly referred to as ITO. In particular, Gauthier states that "[a] conductive coating may include a transparent conducting oxide (TCO) such as indium tin oxide (ITO)." (EX1004, 23:20-23.) Gauthier further explains that examples of transparent substrates with conductive coatings include "ITO-coated glass," and that, in some embodiments, "a substrate with a conductive layer may be ITO-coated glass, or ITO-coated PET." (EX1004, 23:20-28.)

174. Gauthier also confirms that "[a] conductive coating may be an electrode of a switchable film." (EX1004, 23:28-30.) A person of ordinary skill in the art therefore would have understood Gauthier to teach using ITO as the conductive electrode coating for the first electrode layer. Accordingly, in my opinion, Gauthier discloses the subject matter of claim 11.

12. Claim 12: The electrochromic device of claim 1, wherein the second electrode layer comprises a second electrode layer including tin doped indium oxide (ITO).

175. I understand that claim 12 depends from claim 1 and further recites that "the second electrode layer comprises a second electrode layer including tin doped

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indium oxide (ITO).” In my opinion, Gauthier discloses the subject matter of claim 12 for the same reasons discussed for claim 11.

176. As I explained for limitation [1.1], Gauthier discloses the claimed second electrode layer through the conductive coating on substrate/electrode structure 56. Gauthier teaches that a conductive coating on the substrate/electrode structure may include a transparent conducting oxide such as indium tin oxide (ITO), identifies ITO-coated glass and ITO-coated PET as exemplary conductive substrates, and confirms that a conductive coating may be an electrode of a switchable film. (EX1004, 23:20-30.)

177. A person of ordinary skill in the art would have understood Gauthier’s teaching of ITO conductive coatings to apply to both opposing electrode structures in the switchable film, including the second electrode layer 56. Accordingly, in my opinion, Gauthier discloses using tin doped indium oxide, or ITO, for the second electrode layer, and therefore discloses the subject matter of claim 12.

XI. GROUND 3: CLAIMS 2-3 ARE OBVIOUS OVER GAUTHIER IN VIEW OF XU

A. Overview of Xu

178. I have reviewed Xu. Xu is directed to flexible electrochromic panels that, like Gauthier, require reliable sealing of layered electrochromic structures. Xu explains that a flexible electrochromic device must retain spacing between the working electrode and counter electrode and must retain the seal that keeps

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electrolyte between the electrodes, even when the device is flexed. (EX1005, 1:21-31.) In my opinion, a person of ordinary skill in the art would have understood Xu to address the same general technical concern addressed by Gauthier and the '870 patent: protecting an electrochromic stack at its edge regions while maintaining proper device operation.

179. As illustrated in annotated Figure 1 below, Xu's exemplary electrochromic panel includes an electrochromic working layer 28 deposited on an ITO-coated PET substrate 22, an ion-storage/counter layer 26 deposited on another ITO-coated PET substrate 24, and a transparent electrolyte layer 30 sandwiched between the working and counter layers. (EX1005, 5:41-6:42.) In the annotated figure, I have highlighted substrates 22 and 24 to be shown in blue, electrochromic working layer 28 to be shown in red, and barrier 34 to be shown in yellow.

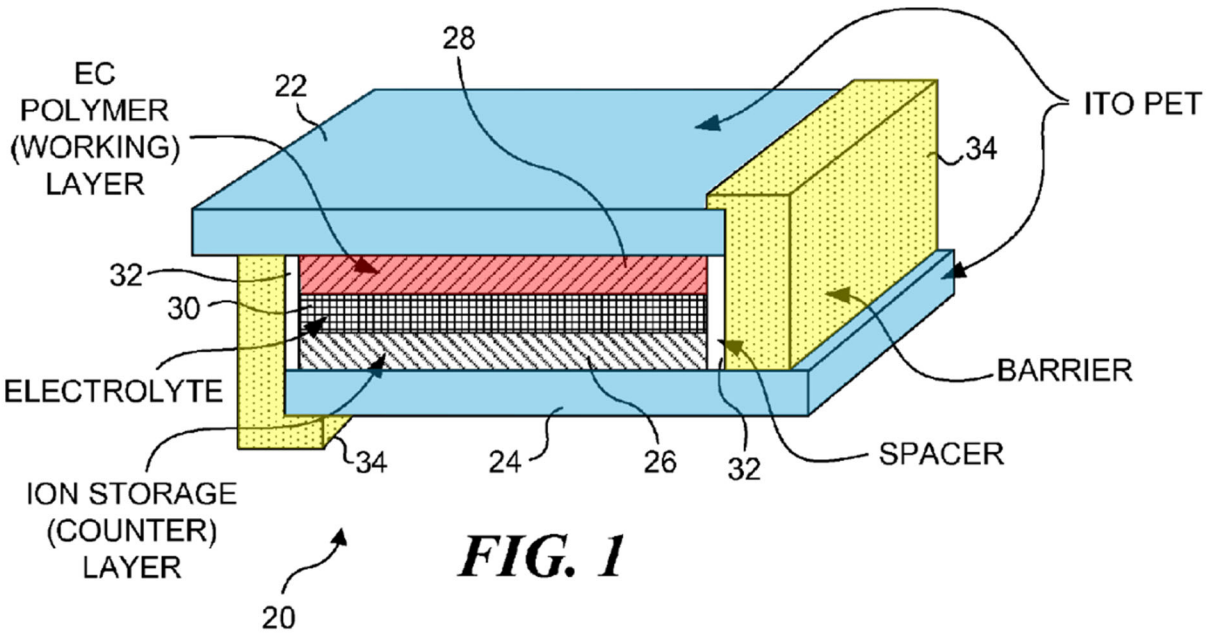


FIG. 1

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EX1005, Figure 1 (annotated).

180. Xu further teaches edge sealing and barrier structures that are directly relevant to claims 2 and 3. In Figure 1, Xu shows barrier 34 at the edge regions of the electrochromic stack. Xu explains that an ultraviolet-light-cured film sealant is used to seal the flexible electrochromic device. Xu further explains that the cured film sealant serves as spacer 32 to maintain a gap between the working and counter electrodes, while also serving as a barrier, in addition to barrier 34, to prevent moisture and oxygen absorption by the display device. (EX1005, 6:42-55.) Xu also teaches that the cured film sealant may itself function as barrier 34, so that separate barrier and spacer elements are not required. (EX1005, 6:55-65.)

181. Xu also confirms the purpose and effectiveness of these edge seals. Xu teaches that, after electrolyte injection, the inlet port is sealed and the device is irradiated with ultraviolet light, causing the sealant "to fully bond between the two substrate layers and to become impermeable to moisture and oxygen." (EX1005, 7:10-21.) Xu further explains that, before UV curing, barriers 34 can be provided "to more fully seal the ends of the layers comprising the flexible ECD." (EX1005, 7:21-24.) Xu's claims likewise recite a barrier disposed around one or more edges to seal the flexible electrochromic panel and prevent entry of liquid and oxygen from the surrounding environment. (EX1005, 12:4-8.)

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182. In my opinion, Xu discloses a closely related electrochromic device in which edge seal or barrier material is used to bond, space, and environmentally protect a layered electrochromic stack. Xu's edge seal/barrier material addresses moisture and oxygen ingress, maintains device spacing, and bonds the flexible electrochromic panel layers together. These are the same types of sealing and environmental-protection functions relevant to the edge protection materials recited in the challenged claims.

183. For Ground 3, I understand that Xu is not being relied on to replace Gauthier's primary disclosure of offset exposed-electrode edge regions and seals 64. Rather, in my opinion, Xu reinforces that an L-shaped edge barrier or seal geometry was a known electrochromic-device sealing implementation for protecting side and surface portions of a layered electrochromic structure against moisture and oxygen ingress. A person of ordinary skill in the art would have considered Xu's edge-seal teachings relevant when implementing or optimizing the edge seals disclosed by Gauthier.

B. Motivation to Combine Xu with Gauthier

184. A person of ordinary skill in the art would have been motivated to modify Gauthier's first seal 64 in view of Xu's barrier seal 34 so that Gauthier's seal extends farther along the top surface of first substrate/electrode structure 54 and the bottom surface of second substrate/electrode structure 56. This modification would

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create a longer "L" leg of the L-shaped edge protection configuration taught by Xu and would provide more surface area for adhesion between Gauthier's first seals and the electrode substrate surfaces. This modification would not change Gauthier's device architecture or the purpose of first seal 64. Rather, it would improve Gauthier's existing edge-seal structure by using Xu's known L-shaped electrochromic edge-barrier configuration to increase adhesion, improve environmental sealing, and more fully protect the exposed offset edge regions shown in Gauthier Figure 6.

185. First, a person of ordinary skill in the art would have been motivated to extend Gauthier's first seal 64 farther over the outer surfaces of substrates 54 and 56 to increase the area of contact between the seal and the electrode substrate surfaces, thereby improving adhesion and mechanical retention of the edge seal. Gauthier expressly recognizes that seal performance depends on available bonding area. Gauthier explains that offsetting the substrate and conductive layer may provide "a larger surface area" for the sealing material to adhere to, whereas a through-cut edge would provide only "a substantially reduced surface area." (EX1004, 6:61-7:3.) A person of ordinary skill in the art would have understood this teaching as encouraging seal geometries that increase seal contact area with the substrate/electrode structures.

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186. Xu reinforces the same design principle by showing L-shaped edge barriers 34 extending around the ends of the electrochromic stack. Xu also explains that barriers 34 may be provided "to more fully seal the ends of the layers" of the flexible electrochromic device. (EX1005, 7:21-24.) In my opinion, a person of ordinary skill in the art would have understood that extending Gauthier's first seal 64 farther onto the outer surfaces of substrates 54 and 56, consistent with Xu's L-shaped barrier arrangement, would increase the contact area between the seal and the substrates. That increased contact area would predictably improve mechanical retention, adhesion strength, and seal reliability at the offset edge regions.

187. Second, a person of ordinary skill in the art would have been motivated to design Gauthier's seal with a longer "L" leg, as taught by Xu, to improve environmental protection of the offset edge regions. Gauthier teaches that seals isolate the switching material from ambient conditions, including air and moisture. (EX1004, 6:41-55.) Gauthier also teaches that suitable seal materials may provide barrier properties, including being gas-impermeable, water resistant, or water impermeable. (EX1004, 17:7-16.) Those teachings would have informed a person of ordinary skill that seal geometry and seal coverage matter for preventing environmental ingress at the vulnerable edge regions of a layered switchable or electrochromic film.

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188. Xu addresses the same problem in an electrochromic device. Xu teaches that its cured sealant becomes impermeable to moisture and oxygen. (EX1005, 6:42-65, 7:10-24.) Xu's Figure 1 further shows L-shaped barriers 34 positioned at the device edges, and Xu explains that the barriers help more fully seal the ends of the electrochromic layers. (EX1005, 7:21-24.) Gauthier already teaches extending first seal 64 along the top surface of first substrate/electrode structure 54 and the bottom surface of second substrate/electrode structure 56. A person of ordinary skill in the art therefore would have been motivated to extend Gauthier's first seal 64 farther over the outer electrode surfaces to create a longer environmental ingress path and more complete edge coverage, thereby improving protection against moisture and oxygen at the exposed edge.

189. Third, Xu provides a known and predictable structure and solution for improving Gauthier's already-disclosed edge seal structure. Gauthier already teaches placing first seal 64 at the offset edge, adjacent to the cut edge of switching material 52 and the exposed electrode region. Gauthier also teaches using second seal 78 to encapsulate the first seal, busbar, and electrical connector. (EX1004, 10:54-11:5.) In addition, Gauthier teaches that second seal 78 may be "a separate application of the same material as the first seal," which supports an integrated or cooperating edge-seal structure extending farther onto the top and bottom surfaces of the first and second substrate/electrode structures. (EX1004, 12:6-9.)

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190. Xu confirms that electrochromic sealant or barrier material can be patterned around device edges, cured, bonded between substrate layers, and used as an environmental barrier. (EX1005, 6:42-65, 7:10-24.) In my opinion, extending Gauthier's first seal 64 farther over the outer surfaces of substrates 54 and 56, consistent with Xu's L-shaped edge barriers 34, would have been a predictable use of known electrochromic film sealing techniques to improve adhesion and environmental protection at Gauthier's offset edge regions. A person of ordinary skill would have understood that the proposed modification uses each reference's sealing teachings for their ordinary purpose and does not require any change to the basic operating principle of Gauthier's device.

C. Reasonable Expectation of Success

191. A person of ordinary skill in the art would have had a reasonable expectation of success in modifying Gauthier's first seal 64 to extend farther along the top and bottom surfaces of substrates 54 and 56, as taught by Xu's L-shaped edge barriers 34. Gauthier's first seal 64 already extends to the top surface of first substrate/electrode structure 54 and the bottom surface of second substrate/electrode structure 56. (EX1004, 10:54-64.) The proposed modification would simply extend that existing seal geometry farther along those same outer surfaces.

192. Gauthier also teaches that seal material may be selected for adhesion to contacted surfaces, including substrates and conductive layers, and for barrier

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properties such as gas impermeability and water/moisture resistance or water/moisture impermeability. (EX1004, 16:64-17:16.) Thus, Gauthier already contemplates seal materials suitable for adhering to the relevant outer electrode surfaces and protecting the overall edge region of the switchable or electrochromic film. A person of ordinary skill in the art would have expected such materials to remain suitable when the seal is extended farther along the same surfaces.

193. Xu confirms that extending electrochromic seal or barrier material around device edges was a predictable and workable implementation. Xu's Figure 1 shows barriers 34 at the edges of the electrochromic stack, and Xu teaches that barriers 34 may be provided "to more fully seal the ends of the layers" of the flexible electrochromic device. (EX1005, 7:21-24.) Xu further teaches that ultraviolet-cured film sealant bonds between substrate layers and becomes impermeable to moisture and oxygen. (EX1005, 6:42-65, 7:10-21.) A person of ordinary skill in the art therefore would have understood that extending Gauthier's first seal 64 "L" leg farther over the top and bottom surfaces of the first and second substrate/electrode structures, in the L-shaped manner taught by Xu, would use known sealant placement and curing techniques for their ordinary purpose: increasing adhesion area and improving environmental sealing.

194. The proposed modification would not require changing Gauthier's electrochromic stack, electrode arrangement, switching material, or busbar

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placement or function. It would merely extend the coverage by adjusting the geometry of Gauthier's existing edge seal so that the seal covers more of the outer electrode surfaces. In my opinion, that type of geometric extension of an existing seal would have been well within the ordinary skill of a person working with layered electrochromic devices and edge-seal materials.

195. Because both Gauthier and Xu use sealant or barrier materials in layered electrochromic devices to bond, seal, and protect against moisture and oxygen, a person of ordinary skill in the art would have expected the modified Gauthier seal to operate successfully. The expected benefits would have been predictable: improved adhesion, improved mechanical retention, a longer environmental ingress path, and improved protection against moisture and oxygen at the exposed edge regions.

D. Claim Element Analysis

1. Claim 2: The electrochromic device of claim 1, wherein: the first edge protection material is in an L shape, further sealing a side surface of the first electrode layer and a portion of an external surface of the first electrode layer.

196. In my opinion, Gauthier in view of Xu renders claim 2 obvious.

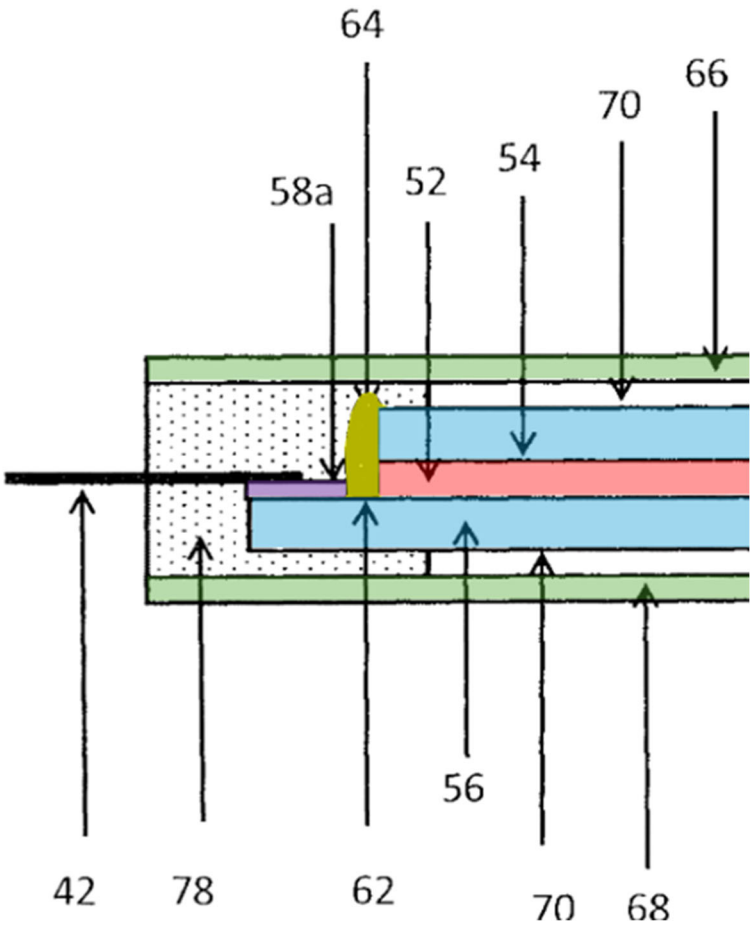
197. As I explained in Ground 2, Gauthier discloses the underlying claim 1 structure, including the first electrode layer, the exposed offset edge region, and first seal 64 corresponding to the claimed first edge protection material. In Gauthier Figure 6, switching material 52 is disposed between first and second

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substrate/electrode structures 54 and 56. Gauthier teaches that portions of the first and second substrate/electrode structures are removed to expose the conductive coating where busbars may be applied, and that first seal 64 is applied in space 62 between the busbar and switching material, adjacent to the cut edge of the switching material. (EX1004, 10:54-64.)

198. In annotated Gauthier Figure 6 below, the left-side first seal 64 is shown in yellow. That seal is located at the left-hand offset edge region where the first substrate/electrode structure 54 is cut back and the conductive coating on the second substrate/electrode structure 56 is exposed. As shown in Figure 6, first seal 64 extends along the side of the cut edge region and onto the top surface of the first substrate/electrode structure 54. Gauthier further teaches that offsetting the electrodes provides access to the conductive surface and may provide "a larger surface area" for the seal material to adhere to. (EX1004, 6:61-7:3.)

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EX1004, Figure 6 (annotated).

199. To the extent Gauthier does not expressly disclose that first seal 64 extends far enough along the top surface of first substrate/electrode structure 54 to satisfy the claimed "L shape," Xu demonstrates a seal with a longer "L" leg that supplies that implementation detail. Figure 1 of Xu shows L-shaped edge barriers 34 at the edge regions of an electrochromic device. Xu teaches that those barriers may be provided "to more fully seal the ends of the layers comprising the flexible ECD [20]." (EX1005, 7:21-24.) Xu further teaches that its UV-cured sealant seals the flexible electrochromic device, maintains electrode spacing, and serves as a barrier

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to prevent moisture and oxygen absorption. Xu also teaches that the cured sealant may itself function as barrier 34. (EX1005, 6:42-65.)

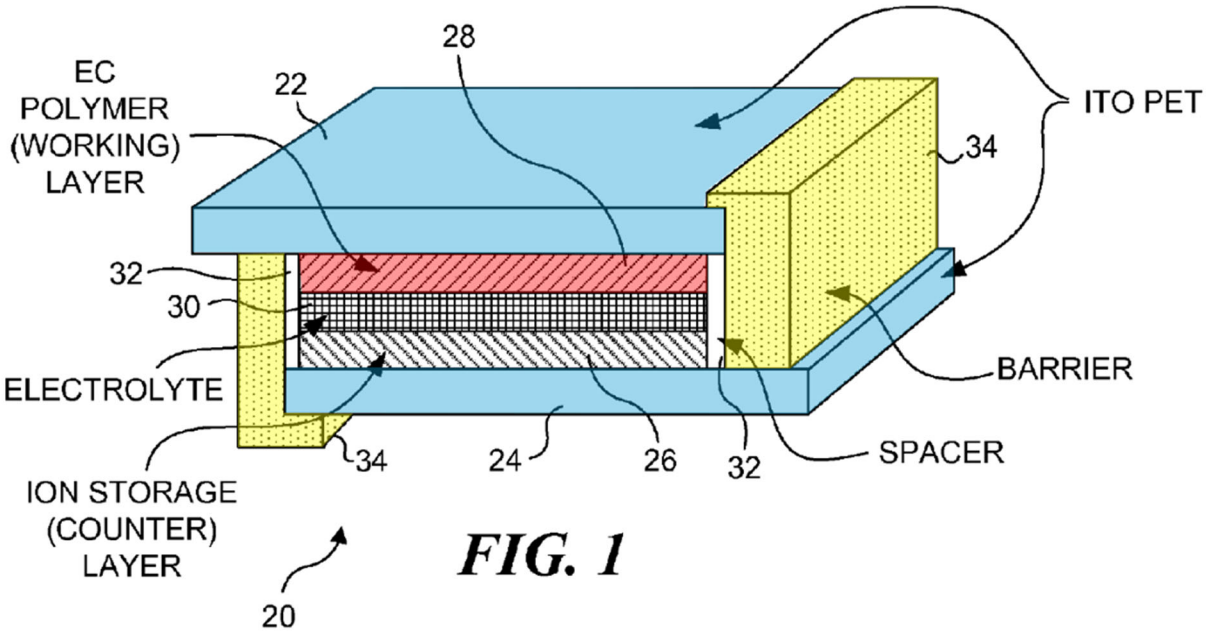


FIG. 1

EX1005, Figure 1 (annotated).

200. In my opinion, a person of ordinary skill in the art would have been motivated to modify Gauthier's first seal 64 so that it extends farther along the top surface of first substrate/electrode structure 54 of the corresponding electrochromic stack, forming the more pronounced L-shaped edge protection geometry taught by Xu's barriers 34. Gauthier's modified seal would still perform Gauthier's disclosed function of sealing the cut edge region and separating the switching material from the busbar region, while providing additional contact area and sealing between the seal and the top surface of the first electrode layer as recited in claim 2. (EX1004, 10:54-64; EX1005, 6:42-65, 7:21-24.)

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201. For the reasons I discussed above in the motivation-to-combine section, this modification would have been obvious. A person of ordinary skill in the art would have been motivated to extend Gauthier's first seal 64 farther over the top surface of the first substrate/electrode structure to increase seal/substrate contact area and improve adhesion, consistent with Gauthier's teaching that larger surface area improves seal adhesion. (EX1004, 6:61-7:3.) This is a straightforward geometric extension of an existing seal along a surface that Gauthier already uses for sealing and adhesion.

202. A person of ordinary skill in the art also would have been motivated to use Xu's longer "L" leg barrier geometry to more fully seal the exposed electrochromic edge region against moisture and oxygen. That motivation is consistent with Gauthier's teaching that seals isolate the switching material from ambient conditions, including air and moisture, and that seal materials may be gas-impermeable, water resistant, or water impermeable. (EX1004, 6:41-55, 17:7-16.) It is also consistent with Xu's teaching that its sealant and barriers protect the electrochromic device from moisture and oxygen and more fully seal the ends of the electrochromic layers. (EX1005, 6:42-65, 7:10-24.)

203. Thus, in my opinion, Xu supplements Gauthier by confirming a known electrochromic edge-seal geometry and implementation detail for improving adhesion and edge protection. A person of ordinary skill in the art would have had a

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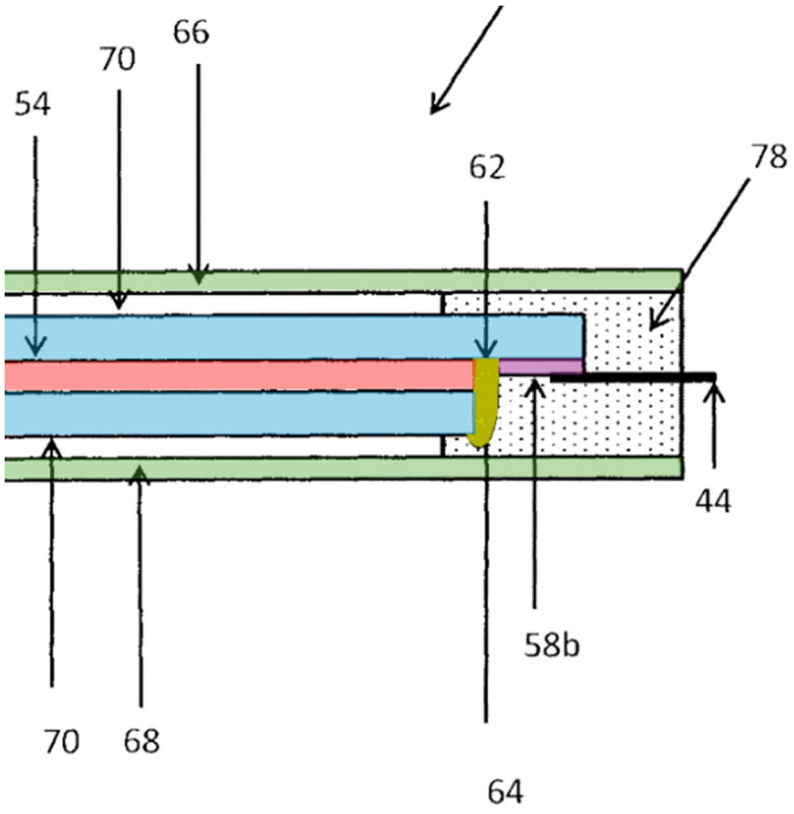
reasonable expectation of success because the modification would merely extend Gauthier's existing first seal 64 along the same substrate/electrode surface using known electrochromic sealant/barrier techniques taught by Xu. Accordingly, Gauthier in view of Xu renders claim 2 obvious.

2. Claim 3: The electrochromic device of claim 1, wherein: the second edge protection material is in an L shape, further sealing a side surface of the second electrode layer and a portion of an external surface of the second electrode layer.

204. I understand that claim 3 depends from claim 1 and recites the same L-shaped edge-protection requirement as claim 2, but for the second edge protection material at the opposite side of the device. In my opinion, Gauthier in view of Xu renders claim 3 obvious.

205. Gauthier discloses corresponding offset edge regions and corresponding first seals 64 on both sides of Figure 6. (EX1004, 10:54-64.) As I explained for limitation [1.5], the right-side first seal 64 corresponds to the claimed second edge protection material. That right-side seal 64 is applied at the offset edge region where the second substrate/electrode structure 56 is cut back to expose the conductive coating on the first substrate/electrode structure 54, and where the seal is positioned between the busbar 58b (purple) and the switching material (red).

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EX1004, Figure 6 (annotated)

206. For the same reasons I discussed for claim 2, it would have been obvious to modify Gauthier's right-side first seal 64 so that it extends farther along the bottom or external surface of second substrate/electrode structure 56 of the corresponding electrochromic stack. That modification would form the more pronounced L-shaped edge protection geometry taught by Xu's barriers 34. Xu teaches that barriers 34 more fully seal the ends of the electrochromic device layers and that the cured sealant provides moisture and oxygen barrier protection. (EX1005, 6:42-65, 7:10-24.)

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207. As I explained above in the motivation-to-combine and reasonable-expectation-of-success sections, a person of ordinary skill in the art would have been motivated to apply Xu's longer "L" leg seal geometry to Gauthier's first seal 64 to predictably increase seal/electrode contact area, improve adhesion of the seal to the electrochromic film, and enhance environmental protection. This modification would not require changing Gauthier's electrochromic stack, conductive coatings, busbar arrangement, or switching-material operation. It would merely extend the geometry of Gauthier's existing right-side seal along the same substrate/electrode surface to improve adhesion and edge protection.

208. Accordingly, in my opinion, Gauthier in view of Xu renders claim 3 obvious. Gauthier provides the underlying offset exposed-electrode edge region and right-side seal 64 corresponding to the claimed second edge protection material, and Xu teaches the known L-shaped edge-barrier geometry that a person of ordinary skill would have applied to more fully seal and protect that edge region.

XII. GROUND 4: CLAIM 5 IS OBVIOUS OVER GAUTHIER IN VIEW OF TONAR

A. Overview of Tonar

209. I have reviewed Tonar. Tonar is directed to electrochromic mirror devices and, like Gauthier, recognizes the importance of perimeter sealing in an electrochromic device. Tonar explains that the perimeter seal bonds the device layers together and seals the electrochromic material within the device. In particular, Tonar

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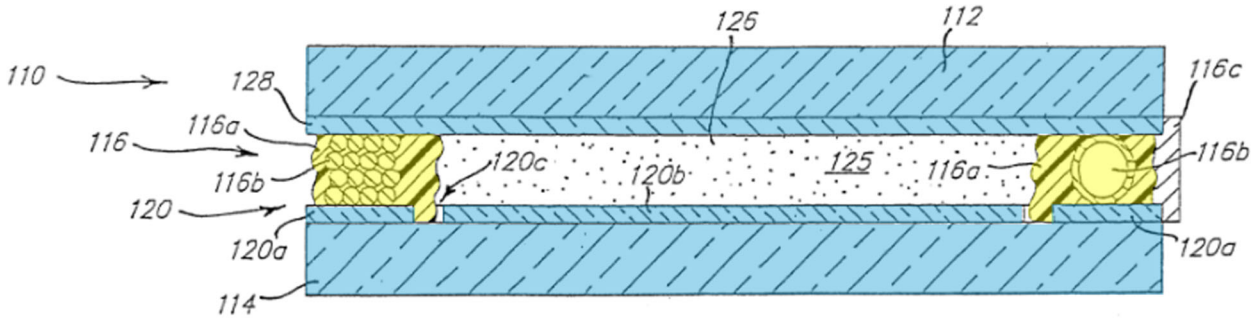
teaches that the seal "must have good adhesion to glass, metals and metal oxides," "must have low permeabilities for oxygen, moisture vapor, and other detrimental vapors and gases," and "must not interact with or poison the electrochromic or liquid crystal material it is meant to contain and protect." (EX1006, 13:8-18.) Tonar further teaches that "epoxy based organic sealing resins are preferred" because of their "excellent adhesion to glass, low oxygen permeability and good solvent resistance." (EX1006, 13:24-39.)

210. Tonar discloses electrochromic devices that include opposing electrode structures. For example, Tonar teaches that a transparent electrically conductive material is deposited "to act as an electrode," and that a reflector/electrode is disposed on the opposing glass element. (EX1006, 14:17-28, 14:40-48.) Tonar further explains that the electrochromic medium is controlled by applying a potential across the reflector/electrode and the transparent electrode, causing the electrochromic medium to darken and attenuate light. (EX1006, 27:44-55.) In my opinion, a person of ordinary skill in the art would have understood Tonar, like Gauthier, to concern a layered electrochromic device having opposed electrodes and a perimeter seal used to contain and protect the electrochromic medium.

211. As illustrated in annotated Figure 5A below, Tonar's seal includes electrically conductive material. Tonar describes Figure 5A as showing "an improved mechanism for applying a drive potential to the layer of transparent

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conductive material." (EX1006, 28:12-18.) In that arrangement, electrical connection is made so that the drive potential travels through reflector/electrode area 120a and "conductive particles 116b in sealing member 116 before reaching the transparent conductor 128." (EX1006, 28:18-27.) Tonar then states that, "[i]n such a configuration, sealing member 116 comprises a typical sealing material, e.g., epoxy 116a, with conductive particles 116b contained therein." (EX1006, 28:36-40.)



EX1006, Figure 5A (annotated)

212. Tonar identifies exemplary conductive particles as "gold, silver, copper, etc., coated plastic" particles. Tonar also teaches coated glass or plastic beads that may provide conductivity and act as spacers. (EX1006, 28:40-50.) A person of ordinary skill in the art would have understood those conductive particles, coated beads, and metal-containing particles to be electrically conductive materials included within the seal. Thus, Tonar expressly discloses an electrochromic-device seal comprising electrically conductive material.

213. Tonar further confirms that the conductive material in the seal must be controlled so the electrochromic device remains operable. Tonar explains that

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conductive particles in sealing member 116 provide a conductive path between the relevant reflector/electrode area and the transparent conductive material. (EX1006, 28:18-27, 28:57-63.) But Tonar also warns that "[n]o conductive particles 116b can be placed" in the other reflector/electrode area "because of the possibility of an electrical short" with the transparent conductive material. Tonar further explains that, "[i]f such an electrical short occurred, the electrochromic device would not operate properly." (EX1006, 28:63-29:5.)

214. In my opinion, Tonar teaches what a person of ordinary skill in the art would have understood: an electrochromic seal may comprise electrically conductive material, but the conductive material should be arranged in a controlled or localized manner so that the seal does not short the opposed electrodes. This is consistent with ordinary electrochromic-device operation, because the opposed electrodes must remain electrically separated except through intended electrical paths and the electrochromic medium.

215. Tonar also discloses practical ways to implement that controlled conductivity. Tonar teaches that "a variety of methods can be used to ensure that no conductive particles 116b enter" the area where they would create a short. (EX1006, 29:6-29.) Those methods include using nonconductive material in selected regions, using a dual dispenser to deposit conductive-particle seal material in one region and nonconductive material in another region, curing a nonconductive seal and then

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adding conductive material into the edge gap, controlling seal flow so the conductive portion remains in the desired region, or placing a conductive member or material on or in the outer edge of the seal. (EX1006, 29:6-29.)

216. Tonar therefore confirms that electrochromic-device seals were known to comprise electrically conductive material in selected portions while remaining sufficiently insulating elsewhere to avoid shorting the device. In my opinion, Tonar's teachings are directly relevant to claim 5 because claim 5 requires edge protection materials that "comprise electrically conductive material," and Tonar provides specific electrochromic-device seal implementations in which conductive material is incorporated into a perimeter seal in a controlled manner.

B. Motivation to Combine Gauthier with Tonar

217. In my opinion, a person of ordinary skill in the art would have been motivated to modify Gauthier's first seals 64 to include Tonar's localized electrically conductive material within the seal, such as conductive particles or a conductive member, while preserving insulating portions of the seal to avoid shorting the opposed electrodes. This modification would not change Gauthier's electrochromic device architecture. Instead, it would implement Gauthier's own disclosure that, "[i]n some aspects, the first seal has low amount of electrical conductivity," and that seals may comprise "metal" or "a metallized tape," or may be overlaid with a metal layer, metal foil, or tape. (EX1004, 3:49-51, 16:63-17:16, 18:65-19:1.) Tonar

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provides a known electrochromic-device implementation for doing exactly that: incorporating electrically conductive material into an electrochromic seal in selected regions while preventing the conductive material from creating a short circuit. (EX1006, 28:36-50, 28:63-29:29.)

218. First, a person of ordinary skill in the art would have been motivated to look to Tonar to implement Gauthier's conductive or metal-containing seal in a known, operable, and controlled manner. Gauthier teaches that its first seal may have a "low amount of electrical conductivity," and further teaches metal-containing seal options. (EX1004, 3:49-51, 16:63-17:16, 18:65-19:1.) A person of ordinary skill in the art would have known that embedding conductive particles, including particles made of or containing metals, in epoxy or other polymeric seals was a known way to impart electrical conductivity to selected portions of a seal. A person of ordinary skill also would have understood that, in an electrochromic film configuration such as Gauthier's, a seal that is conductive across the entire sealed edge region could short the opposed electrode structures and prevent the electrochromic device from operating properly.

219. Tonar expressly confirms this concern and provides a solution. Tonar teaches a sealing member 116 that "comprises a typical sealing material, e.g., epoxy 116a, with conductive particles 116b contained therein." (EX1006, 28:36-40.) At the same time, Tonar warns that conductive particles cannot be placed in certain regions

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"because of the possibility of an electrical short" and explains that, "[i]f such an electrical short occurred, the electrochromic device would not operate properly." (EX1006, 28:63-29:5.) In my opinion, a person of ordinary skill in the art would have been motivated to use Tonar's localized conductive-particle approach to implement Gauthier's electrically conductive or metal-containing seal without creating a continuous conductive path that would short the electrochromic stack.

220. Second, a person of ordinary skill in the art would have been motivated to use Tonar's seal teachings because Tonar provides a practical and predictable way to impart electrical conductivity to an electrochromic seal while maintaining insulating regions where needed. Tonar explains that conductive particles 116b in sealing member 116 provide an electrical path through the seal in a selected region. (EX1006, 28:18-27, 28:57-63.) At the same time, Tonar deliberately separates reflector/electrode regions 120a and 120b with an electrode-free area 120c so "there is no chance of current flow" from one reflector/electrode area to the other. (EX1006, 28:27-31, 28:50-57.)

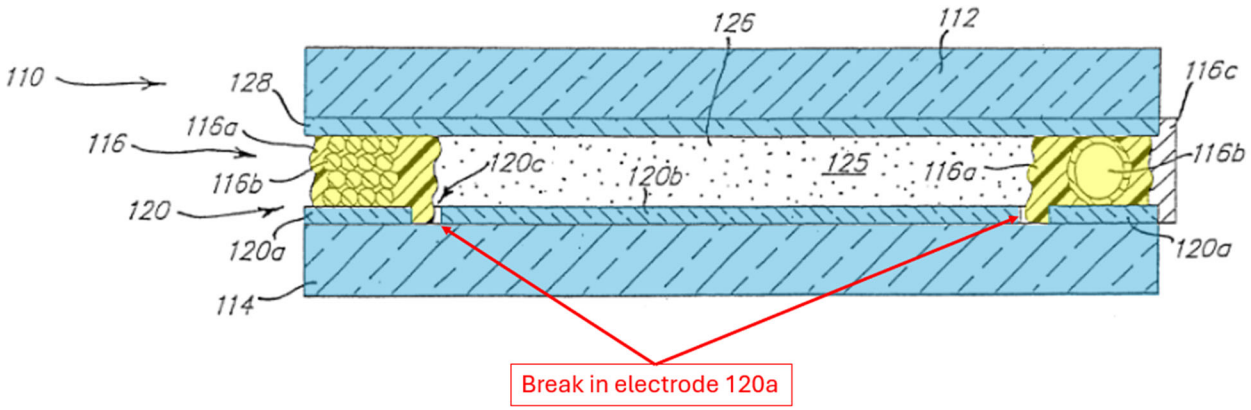
221. Tonar then identifies multiple techniques for keeping conductive particles out of regions where they would cause a short. Those techniques include using nonconductive material in selected areas, using a dual dispenser to deposit conductive-particle seal material in one area and nonconductive material in another, curing a nonconductive seal before adding conductive material, controlling seal flow

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so conductive material stays behind, or placing a conductive member or material on or in the outer edge of the seal. (EX1006, 29:6-29.) A person of ordinary skill in the art would have recognized these teachings as directly applicable to Gauthier's seal 64 because Gauthier already uses seal material at the electrochromic edge regions and teaches similar seal materials, including epoxies and other materials selected for adhesion and barrier properties. (EX1004, 10:54-64, 16:64-17:16.)

222. Third, a person of ordinary skill in the art would have been motivated to look to Tonar because Tonar addresses the same type of design constraint: an electrochromic seal may include conductive material, but the device must not be shorted. Tonar teaches that the seal may include conductive particles, such as gold-, silver-, or copper-coated particles or beads, while still functioning as a perimeter seal for an electrochromic device. (EX1006, 13:8-18, 28:36-50.) Tonar also teaches that the conductive material is not indiscriminately placed throughout the seal. Instead, Tonar controls the placement of conductive material and uses electrode separation features to prevent unintended electrical connection between electrode regions. (EX1006, 28:27-31, 28:63-29:29.)

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EX1006, Figure 5A (annotated)

223. In my opinion, a person of ordinary skill in the art modifying Gauthier's seal 64 would have followed the same principle taught by Tonar: include electrically conductive material in the seal in selected locations to provide desired electrical conductivity, but preserve nonconductive portions, gaps, or controlled placement so current does not short around the electrochromic film. This would have been especially important in Gauthier's structure because Gauthier's first seals 64 are located adjacent to exposed electrode regions and busbars, where uncontrolled conductivity could create unintended electrical paths.

224. This combination is also consistent with the technical meaning of claim 5. Claim 5 recites edge protection materials that "comprise" electrically conductive material; it does not require the edge protection materials to consist entirely of conductive material or to be uniformly conductive throughout. From a technical perspective, if claim 5 were interpreted to require the entire edge protection material to be electrically conductive across the sealed edge regions in a manner that connects

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opposed electrode structures, that configuration would short the device and prevent normal electrochromic operation. Tonar confirms the operable understanding: the seal can comprise electrically conductive material in localized portions while remaining insulating in other portions to avoid an electrical short. (EX1006, 28:63-29:29.)

225. Accordingly, in my opinion, a person of ordinary skill in the art would have been motivated to modify Gauthier's seals 64 to include Tonar's localized conductive particles, conductive member, or other localized conductive material. Doing so would have implemented Gauthier's own teaching of electrically conductive or metal-containing seals in a known, controlled, and operable manner, while preserving the insulating regions needed to prevent a short circuit in the electrochromic device.

C. Reasonable Expectation of Success

226. In my opinion, a person of ordinary skill in the art would have had a reasonable expectation of success in modifying Gauthier's seals 64 to include Tonar's localized conductive material. Both Gauthier and Tonar use perimeter or edge seals in electrochromic devices for the same basic purposes: bonding device layers, sealing electrochromic material, and protecting the device from environmental factors. Gauthier teaches that its seal materials may adhere to substrates, conductive layers, electrodes, and switching material, and may be

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selected for barrier properties such as gas impermeability, water/moisture resistance, or water/moisture impermeability. (EX1004, 16:64-17:16.) Tonar likewise teaches that electrochromic perimeter seals must adhere to glass, metals, and metal oxides, have low permeability to oxygen and moisture vapor, and remain compatible with the electrochromic medium. (EX1006, 13:8-18.) A person of ordinary skill in the art therefore would have understood Tonar's conductive-particle seal implementation to be compatible with Gauthier's electrochromic edge-seal environment.

227. The modification also would have been predictable because embedding conductive particles in polymeric seals, including epoxy seals, was a known way to impart electrical conductivity to a selected seal region. Tonar provides specific working examples of this technique for imparting controlled conductivity to a seal while avoiding a short. Tonar teaches an epoxy sealing member containing conductive particles, such as gold-, silver-, or copper-coated particles or beads, and explains that those conductive particles can provide a localized conductive path through the seal. (EX1006, 28:36-50, 28:57-63.) In my opinion, a person of ordinary skill in the art would have understood this to be a practical and predictable way to make an electrochromic-device seal comprise electrically conductive material.

228. Tonar also teaches how to preserve device operability while incorporating conductive material into the seal. Tonar teaches maintaining electrode-free or nonconductive regions so that conductive particles do not create an electrical

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short, because such a short would prevent the electrochromic device from operating properly. (EX1006, 28:27-31, 28:63-29:29.) In my opinion, those teachings would have given a person of ordinary skill a clear implementation path for incorporating conductive material into Gauthier's seals 64 without creating an unintended conductive path between opposed electrodes.

229. Accordingly, a person of ordinary skill in the art would have expected that incorporating Tonar's localized conductive particles, conductive member, or other localized conductive material into Gauthier's seal 64, while preserving insulating portions or gaps where needed, would predictably provide a seal that comprises electrically conductive material without shorting Gauthier's opposed electrodes. The modification would use known seal materials and known conductive-particle placement techniques for their ordinary purpose, and would not require changing Gauthier's electrochromic stack, switching material, busbar arrangement, or overall device operation.

D. Claim Element Analysis

1. Claim 5: The electrochromic device of claim 1, wherein the first edge protection material and the second edge protection material comprise electrically conductive material.

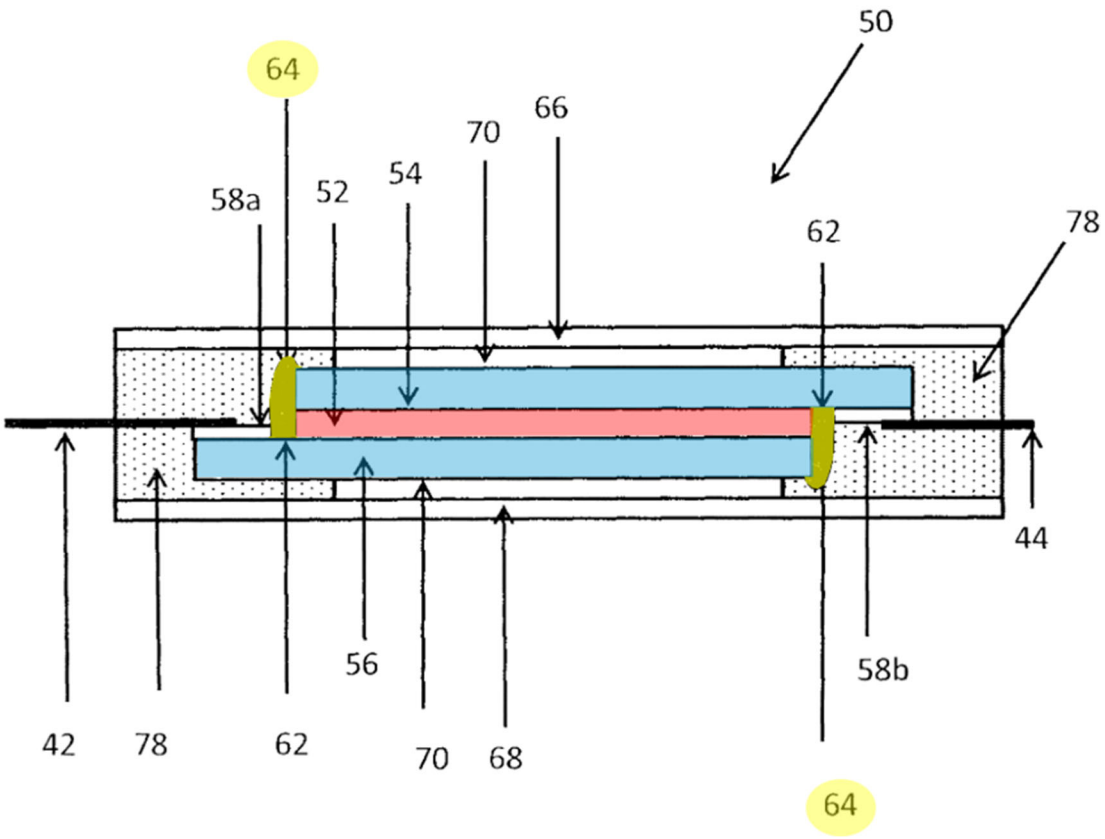
230. I understand that claim 5 depends from claim 1 and recites that "the first edge protection material and the second edge protection material comprise

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electrically conductive material." In my opinion, Gauthier in view of Tonar renders claim 5 obvious.

231. As I explained above in Ground 2, Gauthier discloses the claimed first and second edge protection materials through the left- and right-side first seals 64 shown in Figure 6. As explained for claim 1, Gauthier discloses opposing first and second substrate/electrode structures 54 and 56, with switching material 52 sandwiched between them, offset edge regions exposing conductive coatings for busbar connection, and first seals 64 applied in spaces 62 between the busbars and switching material, adjacent to the cut edge of the switching material. (EX1004, 10:54-64.) Gauthier further teaches that the first seal contacts the cut edge of the switching material, the cut substrate/electrode, and the conductive coating of the uncut substrate, helping maintain the seal in position to ensure suitable sealing of the electrochromic film. (EX1004, 10:51-60.) Thus, Gauthier supplies the first and second edge protection materials recited in claim 5.

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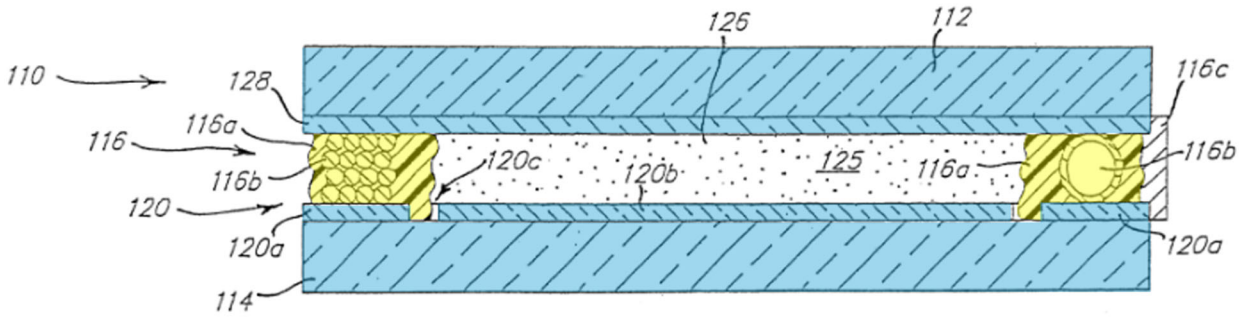
EX1004, Figure 6 (annotated).

232. Gauthier teaches that its first seals 64 may include electrically conductive material. Gauthier states that, "[i]n some aspects, the first seal has low amount of electrical conductivity." (EX1004, 3:49-51.) Gauthier also teaches that seal materials may include "metal" or "a metallized tape," or combinations thereof, and that "[a] seal overlaid with a metal layer or metal foil or tape may be a useful edge seal system." (EX1004, 16:63-17:16, 18:65-19:1.) A person of ordinary skill in the art would have understood metal, metallized tape, metal foil, and metal layers to be electrically conductive materials. Although these teachings already disclose or suggest electrically conductive material in the seal, Tonar provides additional detail

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on how to implement an electrically conductive electrochromic seal in a controlled manner without shorting the device.

233. Tonar teaches an electrochromic-device seal that comprises electrically conductive material in a controlled, localized manner. In connection with Figure 5A, Tonar teaches that "sealing member 116 comprises a typical sealing material, e.g., epoxy 116a, with conductive particles 116b contained therein." (EX1006, 28:36-40.) Tonar explains that conductive particles 116b in sealing member 116 provide a conductive path before reaching transparent conductor 128. (EX1006, 28:18-27, 28:57-63.) Tonar identifies exemplary conductive particles as "gold, silver, copper, etc., coated plastic" particles, and also teaches coated glass or plastic beads that can provide conductivity and act as spacers. (EX1006, 28:40-50.) In my opinion, Tonar confirms that an electrochromic seal may comprise electrically conductive material, including conductive particles, while still functioning as a perimeter seal.



EX1006, Figure 5A (annotated).

234. Claim 5 recites edge protection materials that "comprise" electrically conductive material. From a technical perspective, a person of ordinary skill in the

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art would have understood this language to require that the edge protection materials include electrically conductive material, not that they consist completely of electrically conductive material or are uniformly conductive throughout. That understanding is important because electrochromic devices include opposed electrode structures that must not be unintentionally shorted.

235. Tonar expressly teaches that conductive material in a seal must be controlled to avoid shorting the electrochromic device. Specifically, Tonar explains that reflector/electrode area 120a and reflector/electrode area 120b are separated by an area 120c devoid of reflector/electrode so "there is no chance of current flow" from area 120a to area 120b. (EX1006, 28:27-31, 28:50-57.) Tonar further warns that "[n]o conductive particles 116b can be placed" in reflector/electrode area 120b because of "the possibility of an electrical short" with transparent conductive material 128, and that "[i]f such an electrical short occurred, the electrochromic device would not operate properly." (EX1006, 28:63-29:5.)

236. In my opinion, a person of ordinary skill in the art would have been motivated to modify Gauthier's left- and right-side first seals 64 to include Tonar's localized conductive particles, conductive member, metal-containing material, or other localized conductive material, while preserving insulating portions or gaps where needed to prevent a short between opposed electrode structures. The modified seals would still perform Gauthier's edge-protection function, namely sealing the

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cut edge region adjacent to switching material 52 and the exposed conductive coating/busbar region, while also comprising electrically conductive material as required by claim 5. (EX1004, 10:51-64; EX1006, 28:36-50, 28:63-29:29.)

237. For the reasons I discussed above in the motivation-to-combine and reasonable-expectation-of-success sections for Ground 4, the modification would have achieved predictable results. Tonar provides specific ways to impart electrical conductivity to edge seals, including using conductive particles in epoxy with controlled particle placement, using nonconductive regions where needed, and placing conductive material on or in the outer edge of the seal, while avoiding an electrical short. (EX1006, 28:36-50, 28:63-29:29.) Applying those known techniques to Gauthier's first seals 64 would have predictably yielded seals that include electrically conductive material while preserving insulating portions needed for normal electrochromic operation.

238. Accordingly, in my opinion, Gauthier in view of Tonar renders claim 5 obvious. Gauthier provides the claimed first and second edge protection materials, and Tonar confirms a known and predictable way to incorporate electrically conductive material into electrochromic-device seals in a controlled manner.

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239. I reserve the right to supplement my opinions in the future to respond to any arguments that Patent Owner raises and to take into account new information as it becomes available to me.

240. I understand and have been warned that willful false statements and the like are punishable by fine or imprisonment, or both (18 U.S.C. § 1001). I declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further, that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under § 1001 of title 18 of the United States Code.

241. I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

Executed on May 29, 2026.



Colin A. Wolden

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APPENDIX A

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COLIN A. WOLDEN

Curriculum Vitae

EDUCATION

Massachusetts Institute of Technology
Ph. D. in Chemical Engineering, (1995)
M. S. in Chemical Engineering Practice, (1992)

University of Minnesota
B. S. in Chemical Engineering, (1990)

PROFESSIONAL EXPERIENCE

8/24 – Present
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Research focuses on the development of new materials with application in renewable energy and sustainability. Current research interests include: (1) thin film photovoltaics; (2) membrane reforming of ammonia and methanol; (3) fusion fuel processing; (4) next generation battery materials.

6/22 – Present
Co-founder, Chief Scientific Officer, Blaze Energy Technologies

8/17 – Present
Joint Appointment, National Renewable Energy Laboratory

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Professor, including Interim Head (1/1/15 - 6/30/15, 1/1/17 - 8/30/17)
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Associate Professor with Tenure
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9/97 – 5/02
Assistant Professor
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9/95 – 9/97
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Station Director, Natick, MA
MIT School of Chemical Engineering Practice

9/90 – 5/95
Graduate Research Assistant
MIT Department of Chemical Engineering
Ph.D. Thesis entitled “Critical gas-phase and surface reactions involved in the chemical vapor deposition of diamond.” Research Advisor: Dr. Karen K. Gleason

HONORS, AWARDS, AND PATENTS

- AVS Fellow, 2014.
- CSM Dean’s Excellence Award, 2013.
- E. T. S. Walton Fellow – Science Foundation Ireland, 2010
- Outstanding Educator – Department of Chemical Engineering, 2009
- Order of Omega CSM Outstanding Faculty Award, 2007CSM “Diggers for Diversity Award”, 2005
- NSF Career Award, 2001
- 3M Corporation Untenured Faculty Award, 2000 and 2001
- NRC/ARO Postdoctoral Fellowship, 1995-1997
- Edward Vivian Prize for Excellence in Chemical Engineering Practice, 1992

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- US Patent 20,150,315,035: “Electrochromic tungsten oxide for optical modulation and methods of making the same”, with C.-P. Li, C. Engtrakul, and R. C. Tenent, (2015).
- U. S. Patent 8,623,121, “Stable Catalyst Layers for Hydrogen Permeable Composite Membranes”, with J. D. Way, (2014).
- US Patent App.. 61/895,919: “Plasma-assisted nanofabrication of two-dimensional metal dichalcogenide layers”, C. A. Wolden and R. M. Morrish, (2014).
- US Patent App. 62/033396: “Methods and Devices for Hydrogen Sulfide Removal with H_2 Co-Generation”, Y. Yang, C. A. Wolden, (2014).
- U.S. Patent 8,025,932, “Self-limiting thin film synthesis achieved by pulsed plasma-enhanced chemical vapor deposition”, M. T. Seman, C. A. Wolden, (2011).
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3. "TEM analysis of the phases observed during the growth of oriented diamond on nickel", W. Liu, P. C. Yang, C. A. Wolden, Z. Sitar, R. F. Davis, and J. T. Prater, *Mater. Res. Soc. Symp. Proc.* **423**, 457 (1996).

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SELECTED INVITED & AWARD-WINNING PRESENTATIONS

2025 ***Invited Presentation*** – DOE Tritium Focus Group, Devens, MA "*Direct Internal Recycling Using Palladium Alloy Metal Foil Pumps*", C.A. Wolden, 5/14/25.

2024 ***Invited Presentation*** – Renewable Hydrogen Storage and Transport Conference, Los Angeles, CA, "*Ammonia as a vector for distributed delivery of UHP hydrogen and clean combustion mixtures*", C. A. Wolden, 3/12/24.

2023 ***Invited Presentation*** – Albemarle Lithium, Kings Mountain, NC, "*Scalable Synthesis of Metal Sulfide Nanocrystals for Electrochemical Storage Applications*", C. A. Wolden, 5/25/23.

2023 ***Invited Presentation*** – Hydrogen Powered Future, University of Oklahoma, "*The ongoing saga of Haber & Bosch: Scientists who saved the world, accelerated global warming, and may contribute to climate restoration*", C. A. Wolden, 4/28/04.

2021 European MRS Meeting, Virtual, D. McGott, "Is 3D/2D passivation a secret to success for polycrystalline thin-film solar cells?", 6/2/21. ***Deborah McGott won the Young Researcher Award with this presentation***

2021 ***Invited Presentation*** –Texas Tech University, "*The Role of Ammonia in Enabling H_2@Scale*", C. A. Wolden, 10/15/21.

2019 ***Invited Presentation*** – Future Leaders in Chemical Engineering, North Carolina State University, "*Combinatorial Synthesis of $Mg_xZn_{1-x}O$ (MZO) Thin Films for CdTe Solar Cells*", G. Yeung, Y. Samoilenko, and C.A. Wolden, 10/21/19. ***Gavin Yeung selected to attend this prestigious conference for undergraduate researchers.***

2019 ***Invited Presentation*** – ARPA-E Fusion Workshop, San Francisco "*Advanced Membrane Technologies to Enable an Efficient Tritium Fuel Cycle*", C. A. Wolden, 8/13/19.

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2019 ***Invited Presentation*** – Posters on the Hill, Washington, D.C., K. Hietala, Y. Zhao, W. Smith, and C. A. Wolden, "*Scalable Synthesis of Alkali Sulfide Nanocrystals Using a Bubble Column Reactor*", 5/1/19. ***Kristen Hietala one of 60 undergraduates from around the country who were chosen for this prestigious opportunity. Among these she was one of two students selected to receive the Excellence in Engineering award and $500 from IEEE.***

2018 ***Invited Presentation*** – IOP Advances in Photovoltaics, Loughborough, UK "*Advances in Thin Film CdTe-based Solar Cells*", C. A. Wolden, 9/18/18.

2017 ***Invited Presentation*** – South Dakota School of Mines, Department of Chemical and Biological Engineering, Rapid City, SD "*Green Manufacturing of Alkali Sulfide Nanocrystals for Next Generation Batteries*", C. A. Wolden, 11/7/17

2017 ***Invited Presentation*** – 2017 AIChE Meeting, Minneapolis, MN "*Reactive precipitation of anhydrous alkali sulfide nanocrystals with concomitant abatement of hydrogen sulfide and co-generation of hydrogen*", C. A. Wolden, 11/1/17.

2017 ***Invited Presentation*** - 44th International Conference on Metallurgical Coatings and Thin Films (ICMCTF), San Diego, CA "*Accelerated development of CuSb(S, Se)$_2$ thin film photovoltaics*", C. A. Wolden, 4/24/17.

2016 ***Invited Presentation*** - University of Utah, Department of Materials Science and Engineering, Salt Lake City, UT "*The Evolution of Advanced Front Contacts during CdTe Solar Cell Fabrication*", C. A. Wolden, 4/6/16.

2016 ***Invited Presentation*** - University of New Mexico, Department of Chemical and Biological Engineering, Albuquerque, NM "*The Role of Oxygenated Cadmium Sulfide Window Layers on High Efficiency CdTe Solar Cells*", C. A. Wolden, 1/27/16.

2015 ***Invited Presentation*** - 8th Sino-US Joint Conference of Chemical Engineering, Shanghai, China, "*Development of Earth Abundant Membrane Reactors for Energy Efficient Chemical Processing*", C. A. Wolden, 10/13/15

2014 ***Invited Presentation*** - 47th Meeting of the Korean Vacuum Society, Goseong-gun, South Korea, "*Interface Engineering of Advanced Contacts for High Efficiency CdTe Solar Cells*" C. A. Wolden, 8/18/14.

2013 ***Invited Presentation*** - 2013 Spring MRS Meeting, San Francisco, CA, "*Solution-phase Routes to Cost Reduction for Smart Windows*", C.-P. Li, F. Lin, D. Alie, C. Engtrakul, C. A. Wolden, R. M. Richards, S. Shaheen, R. C. Tenent , 4/3/13.

2013 ***Invited Presentation*** - 9th World Congress of Chemical Engineering, Seoul, Korea, "*Nanoscale control of film thickness, composition, and conformality using plasma-enhanced chemical vapor deposition*", C. A. Wolden, 8/21/13.

2012 Rocky Mountain AVS Symposium, Westminster, CO, "*Fabrication and surface functionalization of asymmetric nanopore arrays*", S. Kelkar, R. Patel, D. Chiavetta, S. Retterer, and C. A.Wolden, 9/20/12. ***Sanket Kelkar won first place in the Graduate Student Poster competition, $500 Prize.***

2012 ***Invited Keynote*** - "*Nanocomposite smart windows for energy efficient buildings*", C. A. Wolden, Smart Surfaces 2012, Dublin, Ireland, 3/9/12.

2012 ***Invited Presentation*** -"*Non-equilibrium Processing of CdTe Absorbers*", C. A. Wolden, Bay Area PV Consortium Annual Meeting, Berkeley, CA, 10/2/12.

2011 ***Invited Plenary Address*** – XVI International Workshop on the Physics of Semiconductor Devices, IIT-Kanpur, India, "*Photovoltaic Manufacturing, Present Status, Future Prospects & Research Needs*", C. A. Wolden, 12/22/11.

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2011 ***Invited Presentation*** - Kansas State University, Manhattan, KS, "*Carbide Composite Membranes for Hydrogen Purification*", C. A. Wolden, 11/8/11.

2011 ***Invited Presentation*** - 58th AVS Symposium, Nashville, TN, "*Plasma Deposition of Carbide-Based Composite Membranes for Hydrogen Purification*", C. A. Wolden, 11/3/11.

2011 ***Invited Presentation*** - CU Materials & Nanoscience Seminar, "*Activation of Hematite Nanorod Arrays for Photoelectrochemical Water Splitting*", C. A. Wolden, 2/12/11.

2010 Student Poster Session, Rocky Mountain AVS, "*Carburization of Molybdenum (VI) Oxide for Synthesis of Mixed Alcohols from Syngas*", A. Pickerell, J. Hensley, J. D.Way, and C. A. Wolden, 9/10. ***Anna was awarded best Poster and $500 prize.***

2009 56th AVS International Symposium, San Jose, CA, "*Room Temperature Synthesis of Silica and SiO_2-TiO_2 Composites for use as Barrier and Anti-Reflection Coatings*", P. C. Rowlette and C. A. Wolden, 11/09. ***Pieter Rowlette won the Thin Film Division Graduate Student Award with this presentation.***

2009 RM-AVS Graduate Poster Competition, Westminster, CO: "*Self-Limiting Deposition of Anatase TiO_2 for Photocatalytic Applications*", N. G. Kubala, F. Wang,, and C. A. Wolden, 9/09. ***Nick Kubala won first place and a $500 cash award.***

2009 RM-AVS Graduate Poster Competition, Westminster, CO: "*Nanoscale Engineering of Mixed Metal Oxide Thin Films for Electronic and Solar Applications*", P. C. Rowlette, M. Canon, and C. A. Wolden, 4/09. ***Pieter Rowlette won second place and a $250 cash award.***

2009 ***Invited Presentation*** - Society of Vacuum Coaters TechCon, Santa Clara, CA "*Fundamental Understanding of Pulsed PECVD Through Diagnostics and Modeling*", Colin A. Wolden, 5/09.

2009 ***Invited Presentation*** - Department of Chemical and Biological Engineering, University of Connecticut, "*Nanoscale Engineering of Mesoscopic Structures*", Colin A. Wolden, 2/09.

2008 ***Invited Presentation*** - Department of Chemical and Biological Engineering, Drexel University, "*Nanoscale Engineering of Mesoscopic Structures*", Colin A. Wolden, 10/08.

2008 ***Invited Presentation*** - 2008 AIChE Annual Meeting, Philadelphia, PA, "*Applying Lessons Learned from an Etching Lab: The Roll of O Atoms in PECVD*", C. A. Wolden, 11/08. Special symposium honoring the distinguished career of Professor Herb Sawin.

2008 ***Invited Participant –*** Scientific Challenges in Solar Energy Conversion and Storage Workshop, Sponsored by the Institute for Mathematics and Its Applications, Minneapolis, MN. 11/1/08.

2008 ***Invited Presentation*** - Department of Chemical and Biological Engineering, Drexel University, "*Nanoscale Engineering of Mesoscopic Structures*", C. A. Wolden, 10/08.

2008 ***Invited Presentation*** - Eindhoven Technical University, Dept. of Applied Physics, "*Self-Limiting Synthesis of Metal Oxide Thin Films by Pulsed PECVD*," C. A. Wolden, 1/08.

2007 54th AVS International Symposium, Seattle, WA, "*Engineering Plasma-Enhanced Chemical Vapor Deposition to Deliver Self-Limiting Deposition of Metal Oxide Thin Films*", M. T. Seman, S. Agarwal, J. J. Robbins and C. A. Wolden, 10/07. ***(Michael T. Seman received the AVS Graduate Research Award with this presentation.)***

2006 ***Invited Presentation*** - Applied Materials, Santa Clara, CA, "*Formation of Chalcogen Containing Plasmas and Their Use in the Synthesis of Thin Film Photovoltaic Absorbers*", C. A. Wolden, 9/06.

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2006 ***Invited Presentation*** - Applied Materials, Santa Clara, CA, "*PECVD Synthesis of Metal Oxides: Precursors, Plasma Chemistry, and Achieving ALD Control with Continuous Processing*", C. A. Wolden, 9/06.

2006 ***Invited Presentation*** - Applied Materials, Santa Clara, CA, "*Electrochromic Films and Devices Produced by Plasma-enhanced Chemical Vapor Deposition*", C. A. Wolden, 9/06.

2005 ***Invited Presentation -)*** Intel Corporation, Portland, OR, "*Development of Plasma Assisted Co-Evaporation (PACE) for thin film semiconductors*", S. Kosaraju and C. A. Wolden, 5/05.

2005 ***Invited Presentation*** - National Renewable Energy Laboratory, Golden, CO, "*Development of Plasma Assisted Co-Evaporation (PACE) for thin film photovoltaics*", S. Kosaraju and C. A. Wolden, 5/05.

2005 Society of Vacuum Coaters, Denver, CO, "*Development of Plasma Assisted Co-Evaporation (PACE) for thin film deposition*", S. Kosaraju, I. Repins, and C. A. Wolden, 4/05. ***(Invited to present in the Heureka! session, describing breakthrough technology)***

2004 ***Invited Presentation*** - National Institute of Standards and Technology, Boulder, CO, "*Molecular Engineering of Oxide Chemical Vapor Deposition*", C. A. Wolden, 12/04.

2004 Materials Research Society Fall Meeting, Boston, MA, "*Controlled Nitrogen Incorporation in ZnO Films Grown by Plasma Assisted Chemical Vapor Deposition*", T. M. Barnes, J. Leaf, K. Olson and C. A. Wolden, 12/04. ***(Teresa Barnes received the MRS Graduate Student Gold Award with this presentation.)***

2004 51st International AVS Symposium, Anaheim, CA, "*HVP-CVD: A Novel Chemical Vapor Deposition Approach for Zinc Oxide Synthesis*", T. M. Barnes, C. Fry, J. Leaf, and C. A. Wolden, ***(Teresa Barnes received the AVS Semiconductor Division Graduate Research Award with this presentation.)***

2004 ***Invited Presentation*** -University of California Santa Barbara, Inorganic Chemistry Seminar Series, "*Transparent Electronic Oxides: Theoretical Design & Experimental Synthesis*", C. A. Wolden, 4/04.

2003 ***Invited Presentation*** - National Renewable Energy Laboratory, "*Plasma Synthesis of Metal Oxide Films for Solar Energy Applications*", C. A. Wolden 7/03.

2001 American Vacuum Society Regional Conference, Arvada, CO, "*Plasma Enhanced Chemical Vapor Deposition of Electrochromic Tungsten Oxide*", A. Chorney and C. A. Wolden, 8/01. ***(as an undergraduate Anna Chorney received 3rd place in the Student Poster Competition competing primarily against graduate students).***

2001 Materials Research Society Spring Meeting, San Francisco, CA, "*Characterization of Chalcocites produced by Thermal and Plasma-assisted Sulfurization*". C. C. Fischer and C. A. Wolden, 4/01. ***(Chris Fischer was awarded the Outstanding Poster in the nationwide Undergraduate Materials Research Initiative competition).***

2000 ***Invited Presentation*** - 3M Corporate Research Center, St. Paul, MN, "*Synthesis of Electronic Oxides*", C.A. Wolden, 11/00.

1998 ***Invited Presentation*** - Gordon Research Conference on Diamond, Oxford, England, "*Diamond Growth at the Center of the C-H-O Phase Diagram: Nucleation, Growth, Texture Development*" C. A. Wolden, 8/98.

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STUDENTS SUPERVISED

- Postdoctoral Scholars (12 to date)
  - Dr. Mingyuan Cao, 2024 - 2025
  - Dr. Rok Sitar, 2023, CEO, Blaze Energy Technologies
  - Dr. Jolie Lucero, 2020 – 2021, Los Alamos National Laboratory
  - Dr. Javishk Shah, 2019 – 2022, HyET NoCarbon
  - Dr. Tommy Fuerst, 2019, Idaho National Laboratory
  - Dr. Simona Ligouri, 2017, Faculty - Clarkson University
  - Dr. Santosh Sahoo, 2013, ASML
  - Dr. Rachel Morrish, 2010-2015, Faculty - Colorado School of Mines
  - Dr. Joe Beach, 2012-2015, Founder - Starfire Energy
  - Dr. William Rance, 2014, Lohnstar Optics
  - Dr. Pieter Rowlette, 2010, Intel
  - Dr. Fengli Wang, 2008 – 2009, Shenzhen Smoore Technology Limited

- Graduate Students: Supervised 28 PhD and 22 MS students advised to date.
  - Michael Aire (ME Chemical Engineering, 5/99) - Non-thesis Masters: Project included initial design and construction of APCVD reactor for CdTe. – Newmont Mining
  - Yoxa Mahathongdy (MS Materials Science, 7/99) - "Statistical optimization & analysis of vapor $CdCl_2$Processing for CdS/CdTe solar cells" – Corning
  - Joshua Robbins (MS Chemical Engineering, 9/00) - "Plasma enhanced chemical vapor deposition and physical characterization of tin oxide thin films". – PhD Candidate, CSM
  - Jie Zhou (PhD Chemical Engineering, 10/01) – "The kinetics of hot-wire chemical vapor deposition of Teflon-like films". – Advanced Solar Power
  - Weican Xiao (MS Engineering, 7/02, co-advised with Tyrone Vincent) – "*In-situ* optical diagnostics of tin oxide thin film synthesis during plasma enhanced chemical vapor deposition": – Unknown
  - James Kestner (PhD - Materials Science, 7/03) – "Development and analysis of vapor transport deposition of Cadmium Telluride Thin Films": – Boeing
  - Joshua Robbins (PhD Chemical Engineering, 7/03) – "Development and analysis of plasma-enhanced chemical vapor deposition of transparent conducting oxides"; – Founder, New Terrain Brewing
  - Michael Seman (MS Chemical Engineering, 5/04) – "Electrochemical and optical characterization of electrochromic tungsten oxide synthesized by PECVD"; – PhD Candidate, CSM
  - Teresa Barnes (PhD Chemical Engineering, 12/04) – "Development of high vacuum plasma-assisted chemical vapor deposition and its application to semiconducting zinc oxide"; – NREL
  - Sreenivas Kosaraju, (PhD Chemical Engineering, 8/05) – "Plasma-assisted co-evaporation synthesis of wide band gap semiconductors" ; – Intel
  - Wenli Yang, (PhD Chemical Engineering, 12/06) – "Plasma-enhanced chemical vapor deposition of titanium oxide thin films for dielectric applications"; – Stion
  - Scott Szymanski, (MS Chemical Engineering, 7/07) – "Self-limiting growth of aluminum oxide thin films by pulsed plasma-enhanced chemical vapor deposition"; – Whiting Petroleum
  - Mike Seman, (PhD Chemical Engineering, 12/07) – "Pulsed plasma-enhanced chemical vapor deposition of metal oxide thin films: Application to electrochromics"; – Co-founder, Resource X
  - Pieter Rowlette, (PhD Chemical Engineering, 12/09) – "Pulsed plasma-enhanced chemical vapor deposition of mixed metal oxides and nanolaminates" ; – Intel
  - Anna Pickerel, (Non Thesis MS Chemical Engineering, 12/10) Project based on synthesis of carbide catalysts for alcohol synthesis form biofuels. – Teacher
  - Nick Kubala, (MS Chemical Engineering, 12/09) – "Self-limiting growth of titanium oxide thin films by pulsed plasma-enhanced chemical vapor deposition"; – Align Midstream
  - Chris Lange, (MS Electrical Engineering, (5/11) "Design and construction of a diagnostic suite for fundamental studies of pulsed PECVD"; – Tacuna Systems LLC
  - Trupti Gawai, (Non Thesis MS Chemical Engineering, 5/11) Project based on pulsed PECVD of oxide films. – Micron
  - Rakhi Patel, (PhD Chemical Engineering, 8/12) – "Pulsed plasma-enhanced chemical vapor deposition of hybrid organic-inorganic nanolaminates"; – Intel
  - Zhaowang Zong, (MS Chemical Engineering, 9/13) – "Electrochromic transistors"; – CSM PhD candidate.

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- Chi-ping Li, (PhD Materials Science, 1/14) – “Scalable synthesis of mesoporous electrochromic tungsten oxide”; –Taiwan OLED manufacturer.
- Jon Kintner: (Non Thesis MS Engineering, 5/14) Project based on CdTe solar cells. – Starfire Energy.
- Christopher Sentman (MS Chemical Engineering, 8/14) – “Pulsed PECVD Synthesis of metal dichalcogenide thin films for sustainable energy applications”; –Poet Biofuels
- Dan Cooney, (MS Chemical Engineering, 9/14) – “Development of BCC metal membranes for H_2 separation”; – ADA Technology
- Sanket Kelkar, (PhD Chemical Engineering, 8/15) – “Design and Fabrication of Asymmetric Nanopores using Pulsed PECVD”; – Micron
- Daniel Meysing, PhD Chemical Engineering, 8/15) – “Development of Ternary Oxides for Use in Advanced Front Contacts in Cadmium Telluride Solar Cells by Magnetron Sputtering”; – First Solar.
- Adam Welch, (PhD Materials Science, 12/15) – “$CuSb(S,Se)_2$ Based Thin Film Heterojunction Photovoltaic Devices”; – Starfire Energy
- Jason Trevithick, (MS Chemical Engineering, 6/16) – “Activation of CdTe solar cells using molecular chlorine”; – Micron
- Jiaojiao Li, (PhD Materials Science, 8/16) – “Development of ZnTe Cu Contacted CdTe Solar Cells”; – Reel Solar Inc.
- Sean T. B. Lundin, (PhD Chemical Engineering 9/17, co-advised with J. D. Way) – “Material and Operational considerations for effective use of palladium composite hydrogen separation membranes. – University of Tokyo
- Tommy Fuerst, (PhD Chemical Engineering, 12/18, co-advised with J. D. Way) – “Catalytic Coatings for Vanadium-Based Hydrogen Membranes”, Idaho National Laboratory
- Yangzhi Zhao, (PhD Materials Science, 9/19, co-advised with Y. Yang), – “Scalable synthesis of lithium sulfide nanocrystals for next generation battery technologies”, - IonBlox, Rath Award Finalist
- Yegor Samoileko, (PhD Chemical Engineering, 1/20), “Development of II-VI ternary alloys for CdTe based solar cells”, Advanced Energy
- Courtney Clark (MS Materials Science, 5/20) Non-thesis Masters: Techno-Economic Analysis and Scale-Up of Lithium Sulfide Production for Use in Next Generation Batteries– Los Alamos National Laboratory
- Zhenyu Zhang, (PhD Chemical Engineering, 12/20, co-advised with J. D. Way), “Design and optimization of catalytic membrane reactors for efficient ammonia synthesis and decomposition”, Cronwell
- Gavin Yeung, (MS Chemical Engineering, 8/21) , “Development of emitter layers for cadmium selenide telluride-based solar cells”, Rocket Lab
- Deborah Clayton-Warwick, (PhD Materials Science, 12/21, co-advised with M. O. Reese), “Development and application of novel thermomechanical liftoff technique for CdTe solar cells”. First Solar – Rath Award Winner
- Will Smith, (PhD Chemical Engineering, 12/22), “Synthesis of Metal Sulfide Compounds for Solid State Electrolytes using Metathesis Reactions”, A123 Systems
- Adam Job, (MS Chemical Engineering, 6/23), “Interfacial Engineering of Dense Metal Membranes for Stable and Cost-Effective Hydrogen Purification in Fusion Relevant Environments”, Ash Grove Cement
- Kevin Prince, (PhD Chemical Engineering, 8/23), “Interfacial engineering and Alternative device architectures for perovskite photovoltaics",Helmholtz-Zentrum Berlin
- Rok Sitar, (PhD Chemical Engineering, 8/23), “Development of catalytic membrane reformer technology as a compact, energy efficient solution for on-site generation of hydrogen and ammonia/hydrogen fuel blends”, CEO Blaze Energy Technologies
- Liz Golonski, (MS, Chemical Engineering, 5/24), “Analysis of nitrogen oxide emissions produced during combustion of cracked-ammonia fuels”, West Point
- Chao Li, (PhD, Chemical Engineering, 8/24), “Palladium-based metal foil pumps for direct internal recycling of hydrogen isotopes in the fusion fuel cycle”, Marathon Fusion
- Saeed Ahmadi Vaselabadi, (PhD, Chemical Engineering, 12/24), “Solution synthesis of sodium-based multinary chalcogenides for next-generation battery applications”, Virginia Tech University
- Cameron Burst, (MS, Materials Science, 8/25), “Composite titanium-vanadium membranes for high temperature hydrogen purification”, Mines
- Sean Mathews, (MS, Chemical Engineering 8/25), “Evaluation of nickel-based perovskite catalyst for low temperature ammonia decomposition”
- Andrea Mathew, PhD Candidate, Materials Science
- Nolan Kelley, PhD Candidate, Chemical Engineering

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- Ben Ivie, PhD Candidate, Advanced Energy Systems
- Garrett Strain, MS Candidate, Chemical Engineering
- Vitor Camacho, PhD Candidate, Chemical Engineering

- Created and supervised undergraduate research opportunities for 78 students (with graduate school attended)
  - Class of 1999: Andrew Barleben
  - Class of 2000: Robert Alexander, Logan Hagaman (California Institute of Technology)
  - Class of 2001: Darren Odom, Devin Dyar, Jim Huang
  - Class of 2002: Dustin Rice, Amanda Overmeyer (CSM), Chris Fischer (MIT), Mailasu Bai (CSM), Brent Lutz (University of Florida), Michael Eaton (CSM), Stephen Kelley (Stanford), Anna Chorney (Penn State)
  - Class of 2003: James Esteban, Jason Litzinger, Nathan Torres
  - Class of 2004: Jackie Leaf, Steve Hand, Cassandra Fry (CSM)
  - Class of 2005: Kyle Olson, John Harvey
  - Class of 2006: Joey Marino, Alex Monson, Hideto Hagiya, Scott Szymanski (CSM)
  - Class of 2007: Audrey Nelson, James Condon
  - Class of 2008: David Richards (Purdue), Nick Kubala (CSM)
  - Class of 2009: Olivia Bromley, Amy Dubetz (Tulane)
  - Class of 2010: Marilou Canon, Rambert Nahm (Cornell), Cody Willingham (CSM)
  - Class of 2011: Bas van de Loo (TU/e), Rene Vervuurt (TU/e), Alex Sale, Donal Finegan (University College London)
  - Class of 2012: Sterling Parks, Sara Chmelka, Karl Brennan (Cornell), Amanda Fankel
  - Class of 2013: Becky Silverstein, David Chiavetta, Maria O'Brien (Trinity College Dublin), Aisling Brazel
  - Class of 2014: Amy Goldstein, Trevor Haak, Eoin McMullan, Sirichat Rojnirun
  - Class of 2015: Colm O'Riada (University of Cambridge)
  - Class of 2016: Alice Brennan, Miranda McCeig
  - Class of 2017: Emily White
  - Class of 2018: Elias Petsalis (CSM), Lucy Fitzgerald
  - Class of 2019: Kristen Hietala, Gavin Yeung (CSM)
  - Class of 2020: Daisy Fuchs (CU), Sarah Livingston
  - Class of 2021: Hope Wikoff, Arthur Harris, Jerry Birnbaum, Isaiah Thurman
  - Class of 2022: Jane Turek, Ben Reinecke
  - Class of 2023: Alexandria D'Aquila, Katie Palmer (CSM), Gordon Huang, Sean Mathews (CSM)
  - Class of 2024: Izzy Roszell, Cameron Burst (CSM), Emma Neuroth (CSM)
  - Class of 2025: Kagan Killough (Bordeaux), Brynn Benham
  - Current Students: Ben Bauerle, Caroline Hufnagel, John Braford, Vivian Aldinger, Gwenyth Lemon, Ceiwen Wick

RESEARCH CONTRACTS

I have been the PI or co-PI on initiatives on awards valued at ~$21.6M to CSM (my portion ~$15.5M). The sources include an array of sources including NSF, DOE, ARPA-E, and private industry. The Table below summarizes research contracts secured in the past decade.

Project Title	**Amount / Dates**	**Source**	**Collaborators**
Direct Internal Recycling for High Field and Spherical Tokamaks	$2,592,472 7/15/25 – 7/14/30	DOE	Scott Walton (NRL) Sub: $597K
High Throughput Testing of Metal Foil Pumps	$360,000 6/1/25 – 5/31/28	INL	
Synthesis and Characterization for CdTe	$210,000 12/18/24 - 12/17/27	NREL	Matt Reese (NREL)
Low-cost III-V solar cells through mechanical spalling and substrate reuse	$270,000 10/1/24 -9/30/27	NREL	PI C. Packard
INFUSE: Testing of Engineered Membranes in Fusion-Relevant Metal Foil Pumps	$100,000 9/1/24 - 8/31/25	DOE	
Scalable, Low-Cost Hydrogen Delivery Systems	$987,954 1/1/24 -12/31/26	EERE	
Green Hydrogen Laboratory	$3,000,000	DOE	PI R. J. Kee

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	1/1/24 -12/31/26		
Fabrication and Characterization of Tandem Photovoltaics Architectures	$70,000 1/1/23 – 6/30/24	NREL	Lance Wheeler (NREL)
Distributed Production of Green Hydrogen	$200,000 1/1/23 – 12/31/24	COEDIT	
Ammonia/Hydrogen Fuel for Clean Combustion	$35,000 5/1/22 - 8/31/23	COEDIT	
Manufacturing of Metal Sulfides for Next Generation Batteries	$379,765 9/1/22 -8/31/25	NSF	
CdTe Core	$209,720 9/28/21 – 8/27/24	NREL	Matt Reese (NREL)
Interfacial-engineered Membranes for Efficient Tritium Extraction	$1,397,972 1/1/21- 6/30/24/	ARPA-E	Sub: INL ($260K)
Nanomaterials for Next Generation Solid State Batteries	$141,293 11/21/19 - 12/31/21	COEDIT / SolidPower	
Intensification and Integration of Hydrogen and Ammonia Production	$2,247,676 1/1/19 – 7/11/24	ARPA-E	Co-PI J.D. Way
Interdigitated Back Contact Solar Cells for Switchable Photovoltaic Windows	$206,454 1/1/19 - 9/30/21	DOE/NREL	Lance Wheeler (NREL)
Development of advanced materials and characterization techniques for hydrogen carriers	$527,119 1/1/19 – 9/30/23	NREL	PI B. Trewyn
High Specific Power Solar Cells	$227,000 1/1/18 – 12/31/21	ONR/NREL	Matt Reese (NREL)
Continuous Manufacturing of Anhydrous Metal Sulfide Nanocrystals	$387,192 9/15/18 -8/30/21	NSF	
Methane Aromatization in a Membrane Reactor	$34,679 5/1/18 -10/9/18	TDA Research	
Addressing Unresolved Scientific Challenges for CdTe-based Solar Cells	$336,051 7/15/17 - 6/30/20	NSF	
Membrane Reactor Synthesis of Ammonia at Moderate Conditions	$500,000 10/1/16 – 7/31/18	ARPA-E	PI J.D. Way
Earth Abundant Membrane Reactors for Efficient Chemical Processing	$329,615 5/1/15 - 4/30/19	NSF	Co-PI J.D. Way
Scalable Manufacturing of Nanostructured Lithium Sulfide	$39,000 4/1/16 – 4/30/18	COEDIT	Co-PI Y. Yang
Accelerating Development of CdTe Solar Cells	$125,000 12/1/16 – 6/30/17	BAPVC	Co-PIs T. Ohno, J. Beach
Advanced Membranes for Tritium Purification	$155,000 9/1/15 - 8/31/18	DOE NEUP	Co-PI J.D. Way
MRI: Acquisition of a coupled optical and scanning probe microscopy facility for advanced materials research	$328,114 5/1/15 -12/31/18	NSF	Co-PI K. Neeves
Flexible Multi-Functional Coatings to Enable Advanced Optoelectronics	$150,000 1/1/14 – 12/31/15	COEDIT	
Low-cost highly transparent flexible low-e coating film	$50,000 10/1/13 – 9/30/14	ITN Energy	
Non-Equilibrium Processing of CdTe Absorbers to Enable 20% Efficiency	$599,724 1/1/13 – 12/31/15	BAPVC	Co-PIs T. Ohno, J. Beach
Rapid Development of Earth-Abundant Thin Film Solar Cells	$179,456 1/22/13 -1/21/16	NREL	Andriy Zakutayev (NREL)
Fabrication of Pd Ternary Alloy Membranes	$200,000 8/8/12 – 12/31/15	Pall Corporation	PI J.D. Way
Synthesis of Stoichiometric Pyrite Photovoltaic Absorbers	$196,000 6/1/12 -5/31/2015	NSF	
High Temperature, Roll-to-Roll CdTe Superstrate	$219,843	NREL	Teresa Barnes

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Devices Using Flexible Glass	1/1/12 – 8/31/15		(NREL)
Catalyzing Innovation and Collaboration for Photovoltaics Research and Development: An NSF Workshop	$58,925 3/19/10 -1/31/12	NSF	
Asymmetric Nanopores for Fundamental Studies of Hindered Transport	$304,912 9/1/10– 8/31/14	NSF	
Integration of Electro-Catalysts With Nanostructured Absorbers for Photoelectrochemical Production of Hydrogen	$45,454 9/1/10– 8/31/14	CRSP	
Metal Carbide Catalysts for Synthesis of Alcohols from Synthesis Gas	$85,098 1/1/14– 1/14/11	NREL	PI J.D. Way
Nanoporous, Metal Carbide, Surface Diffusion Membranes for High Temperature Hydrogen Separation	$998,543 10/1/09 - 9/30/13	DOE	PI J.D. Way

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