



(51) International Patent Classification:

H05K 5/04 (2006.01) *B32B 38/08* (2006.01)
B23K 35/02 (2006.01) *H05K 5/03* (2006.01)
B32B 38/00 (2006.01) *H05K 5/00* (2006.01)

(21) International Application Number:

PCT/US2014/047257

(22) International Filing Date:

18 July 2014 (18.07.2014)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

61/856,303 19 July 2013 (19.07.2013) US

(71) Applicant: **MATERION CORPORATION** [US/US];
 6070 Parkland Boulevard, Mayfield Heights, OH 44124
 (US).

(72) Inventors: **RAMESH, Kothandapani**; Block 562, Ang
 Mo Kio, Avenue 3, #06-3495, 560562 (SG). **KONG, Lee,
 Chee**; 25 Woodleigh Close, #05-20 Euro Asia Park,
 357920 (SG).

(74) Agent: **KLEIN, Richard, M.**; Fay Sharpe LLP, The Halle
 Building, 5th Floor, 1228 Euclid Avenue, Cleveland, OH
 44115-1843 (US).

(81) Designated States (unless otherwise indicated, for every
 kind of national protection available): AE, AG, AL, AM,
 AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,
 BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM,
 DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
 HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR,
 KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME,
 MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ,
 OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA,
 SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM,
 TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM,
 ZW.

(84) Designated States (unless otherwise indicated, for every
 kind of regional protection available): ARIPO (BW, GH,
 GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ,
 UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ,
 TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK,
 EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV,
 MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,
 TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW,
 KM, ML, MR, NE, SN, TD, TG).

Published:

— without international search report and to be republished
 upon receipt of that report (Rule 48.2(g))

(54) Title: A METAL CAP ASSEMBLY FOR OPTICAL COMMUNICATIONS

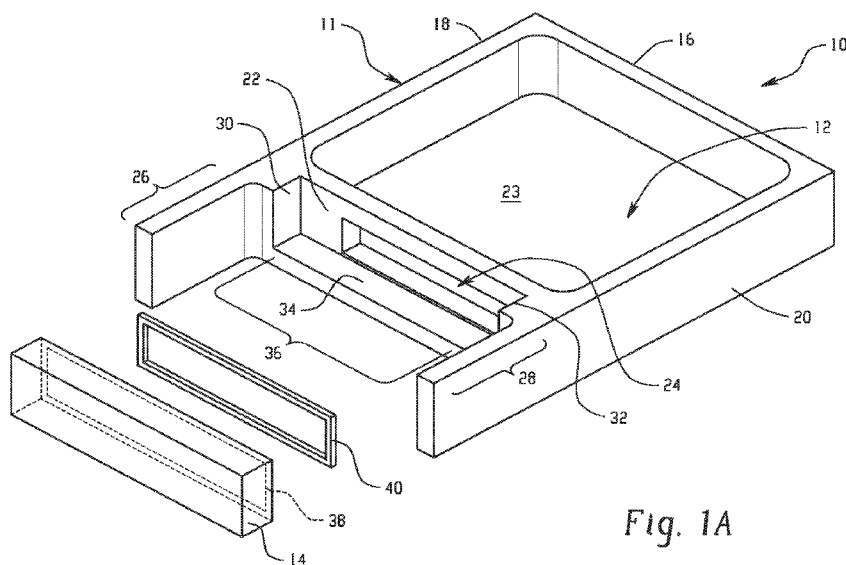


Fig. 1A

(57) Abstract: A cap assembly for optical communications comprising a housing that includes a front side perpendicular from a bottom side, opposing parallel first and second sides perpendicular from the bottom side, and a back side disposed perpendicularly between the first side and the second side offset from respective ends of the first side and the second side opposite the front side. The back side includes an opening there-through and a three-sided ledge formed along an interior of the first side leg, an exterior of the back side, and an interior of the second side leg. The cap assembly further includes a window configured to contact the three-sided ledge of the back side, the glass panel covering the opening there-through and attached to the assembly via a solder pre-form.

A METAL CAP ASSEMBLY FOR OPTICAL COMMUNICATIONS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Patent Application Serial No. 61/856,303, filed July 19, 2013 and titled VISI-CAP (OPTICAL COMMUNICATIONS CONTAINER), the entirety of which is incorporated by reference herein.

BACKGROUND

[0002] The subject disclosure is directed to the communication arts, the optical communications arts, the metallurgical arts, the container fabrication arts, the coating arts, the plating arts, and the like.

[0003] Optical communications are being used to replace current radio-wave communications, as radio-waves inherently limit the data transmission speed and may have some potential negative health effects. Optical communications is communication at a distance using light to carry information and uses a transmitter that encodes data into an optical signal, a channel that carries the light to a destination, and a receiver that receives the light and reproduces the information. Optical fiber is one of the most common types of channels for optical communications, although direct communication via air is also possible.

[0004] A problem with optical communication components involves the contamination of the light containing the message with exterior light sources, e.g., ambient light. Filtering is generally used to restrict the receipt of light by a receiver to a particular wavelength, generally associated with the wavelength particular to the transmitter, e.g., LED, laser diodes, etc. In enclosed systems, such as wired optical communication systems, various types of particulates (dust, etc.), moisture (water vapor, etc.) can affect and degrade the performance of data transmission, e.g., loss of data, slower times to compensate for post-reception filtering, lower bandwidth, etc.

[0005] In such enclosed systems, attachment of a filter can be an expensive and time consuming fabrication process. AR coatings generally do not react well to metallization sealing structures, and thus the coating cannot extend to all portions of a filter. The precise

layering in small areas is problematic and leads to loss in output due to defective components, e.g., coating extended to non-coated area and bonding is not possible, and the like.

[0006] Thus, it would be advantageous to provide an assembly that is capable of providing a hermetically sealed environment for optical communications.

[0007] It would further be advantageous to provide a window that allows for optical communications with respect to the assembly.

[0008] It would further be advantageous to provide an assembly and filter capable of hermetic sealing against elements that can be readily adapted to a variety of applications, such as optical communication ports, optical transceivers, optical bridges, direct communication interfaces, and the like.

BRIEF DESCRIPTION

[0009] In one aspect of the exemplary embodiment, a cap assembly is provided that comprises housing. The housing includes a front side perpendicular from a bottom side, opposing parallel first and second sides perpendicular from the bottom side, and a back side disposed perpendicularly between the first side and the second side offset from respective ends of the first side and the second side opposite the front side. The back side includes an opening there-through and a three-sided ledge formed along an interior of the first side leg, an exterior of the back side, and an interior of the second side leg. The cap assembly further includes a window configured to contact the three-sided ledge of the back side, the glass panel covering the opening there-through.

[0010] In another aspect, a method of forming at least one window for attachment to a metal cap assembly is provided. The method includes coating each side of an associated wafer, and forming a pattern on one side of the associated wafer. The method further includes layering a metallization seal ring onto the pattern, and dicing the wafer in accordance with the pattern to form the at least one window.

[0011] In another aspect, a solder pre-form for hermetically sealing a multi-coated glass panel having a metallization seal ring layered around a perimeter of one side thereof to a cap assembly including a plated metal housing is provided. The pre-form includes at least

one layer of gold and at least one layer of tin, wherein the pre-form is sized to affix to the metallization seal ring.

[0012] In accordance with one embodiment, there is provided a metal cap assembly comprised of an iron-nickel-cobalt alloy having a similar expansion behavior to that of borosilicate glass.

[0013] In another embodiment, there is provided a metal cap assembly coated in nickel and gold plating scheme that allows the cap assembly to accept and bond to a coated glass panel or window, as well as to allow application of the cap assembly to a silicon substrate.

[0014] In another embodiment, there is provided a window component that is selectively coated on each side, with a metallization seal ring affixed or deposited on one side to allow attachment and sealing of the window to the cap assembly.

[0015] In another embodiment, there is provided one or more gold-tin preforms in varying compositions that facilitate the joining of the window to the cap assembly and the cap assembly to a silicon substrate.

[0016] In such an embodiment, the one or more pre-forms may have different melting temperatures.

[0017] In another embodiment, a two stage solder joint of glass and metal seal applications is provided. A gold-tin eutectic alloy is used for sealing glass to metal via a solder as it melts at 280 °C, e.g., 80/20 Au/Sn solder alloy. A second solder, which melts with lower temperature, is used to join the metal to a substrate, e.g., 90/10 Sn/Au solder alloy which melts 217°C, thereby completing a hermetically sealed interior within the metal cap assembly.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] The following is a brief description of the drawings are presented for the purposes of illustrating exemplary embodiments disclosed herein and not for the purposes of limiting the same.

[0019] FIGURE 1A is a three-dimensional view of a cap assembly in accordance with one embodiment of the present disclosure.

[0020] FIGURE 1B is a top view of the cap assembly of FIGURE 1A in accordance with one embodiment of the present disclosure.

[0021] FIGURE 1C is a side view of the cap assembly of FIGURE 1A and FIGURE 1B in accordance with one embodiment of the present disclosure.

[0022] FIGURE 1D is a photograph of a back view of a prototype of the cap assembly shown in FIGURES 1A-1C without a glass panel attached in accordance with one embodiment of the present disclosure.

[0023] FIGURE 1E is a photograph of a first front side view of the prototype of the cap assembly shown in FIGURE 1D with the glass panel attached in accordance with one embodiment of the present disclosure.

[0024] FIGURE 1F is a photograph of a back view of the prototype of the cap assembly shown in FIGURES 1D-1E with the glass panel attached in accordance with one embodiment of the present disclosure.

[0025] FIGURE 1G is a photograph of a second front view of the prototype of the cap assembly shown in FIGURES 1D-1F with the glass panel attached in accordance with one embodiment of the present disclosure.

[0026] FIGURE 2 illustrates the glass panel with metallized seal ring for used with the cap assembly of FIGURES 1A-1G in accordance with one embodiment of the present disclosure.

[0027] FIGURE 3 is a flowchart illustrating the production of the glass panel of FIGURE 2 for use with the cap assembly of FIGURES 1A-1G in accordance with one embodiment of the present disclosure.

[0028] FIGURE 4 graphically illustrates a reflectivity of the glass panel of FIGURE 2 in accordance with one embodiment of the present disclosure.

[0029] FIGURE 5 graphically illustrates a transmission of the glass panel of FIGURE 2 in accordance with one embodiment of the present disclosure.

[0030] FIGURE 6 illustrates a solder pre-form for use in attachment of the glass panel of FIGURE 2 to the cap assembly of FIGURES 1A-1G in accordance with one embodiment of the present disclosure.

[0031] FIGURE 7 illustrates a solder pre-form for use in attachment of the cap assembly of FIGURES 1A-1G to a substrate in accordance with one embodiment of the present disclosure.

[0032] FIGURES 8A-8B illustrate varying measurements of implementations of the glass panel in accordance with embodiments of the present disclosure.

[0033] FIGURES 9A-9D illustrate varying measurements of implementations of the glass panel in accordance with embodiments of the present disclosure.

[0034] FIGURE 10 illustrates a stack assembly of the solder pre-form, metallization seal ring and glass window in accordance with embodiments of the present disclosure.

[0035] FIGURE 11 illustrates a functional block diagram depicting a fabrication process of the cap assembly in accordance with one embodiment of the subject disclosure.

[0036] FIGURE 12 illustrates a functional block diagram depicting a fabrication process of the window for the cap assembly in accordance with one embodiment of the subject disclosure.

DETAILED DESCRIPTION

[0037] One or more embodiments will now be described with reference to the attached drawings, wherein like reference numerals are used to refer to like elements throughout.

[0038] Turning now to FIGURES 1A-1C, there are shown varying views (three-dimensional in FIGURE 1A, top view in FIGURE 1B, and side view in FIGURE 1C) of an exemplary image of a cap assembly **10** in accordance with one embodiment of the subject disclosure. As shown in FIGURES 1A-1C, the cap assembly **10** includes a housing **11** that has a front side **16**, a first side **18**, a second side **20**, a back side **22**, and a bottom **23** forming a cavity **12** therein. The sides **16-22** are suitably positioned perpendicularly to the bottom **23** so as to form the cavity **12**. In accordance with one embodiment, the housing **11** of the cap assembly **10** may be plated with one or more selected layers, such as a nickel layer and a gold layer. In such an embodiment, the plating may be an electrolytic plating of nickel at 4.31 μm and an electrolytic plating of gold at 0.5 μm .

[0039] The back side **22** is located perpendicularly between the first side **18** and the second side **20**, offset from respective ends of the first side **18** and the second side **20**. The portion of the first side **18** that extends past the back side **22** is the first leg **26** and the portion of the second side **20** that extends past the back side **22** is the second leg **28**. In

accordance with one embodiment, the first and second legs **26** and **28** are sized so as to reduce noise during transmission of light, as discussed more fully below.

[0040] As shown in FIGURES 1A-1C, the back side **22** includes an opening **24** that extends through the back side **22** into the cavity **12**. Formed along the lower perimeter of the back side **22** is a three-edged ledge **36** that consists of a first portion **30** on the interior of the first side leg **26**, a second portion **32** on an interior of the second leg **28**, and a third portion **34** located along a lower portion of an exterior of the back side **22**. The process by which the housing **11** of the cap assembly **10** is fabricated is illustrated in the example depicted in FIGURE 11. As shown in FIGURE 11, fabrication may utilize machining, such as electrical discharge machining (wire EDM), mechanical machining, forging, or the like. Plating of the housing **11** includes nickel and gold as discussed elsewhere in the instant disclosure.

[0041] As shown in the example fabrication process of FIGURE 11, after receipt of a Fe-Ni-Co rod (e.g., KOVAR), the element composition and impurity data of the received rod is first reviewed. After determining the material is in accordance with predetermined values, the dimensional values of the rod are determined. It will be appreciated that the size of the cap assembly **10** may vary depending upon the implementation of the completed assembly. As such, the dimensions of the rod are analyzed to ascertain whether sufficient material exists for forming the assembly **10**. An electrical discharge machine may then cut the outer line of the assembly **10** from the rod, following individual slicing of the assemblies **10** formed therefrom. The individual assemblies **10** may then be partially finished (e.g., grinding, burr removal, etc.) prior to testing. Measurements as to the thickness of the cap assemblies are then made. Assemblies **10** meeting predetermined standards for thickness are then hollowed out, i.e., cavity formation, and window opening formation via EDM. After a final dimension measurement, the assemblies **10** meeting the predetermined standards are plated in Ni and Au.

[0042] The cap assembly **10**, as shown in FIGURE 1A further includes a window **14** that is sized to contact the three-sided ledge **36** of the housing **11**. Turning now to FIGURE 3, there is shown a flowchart illustrating a process for forming the window **14** for use in the cap assembly **10**. It will be appreciated that the simplified method illustrated in FIGURE 3 is associated with the 97% transmission and less than 0.5% reflectivity at 1310

nm wavelength discussed above. Beginning at **302**, both sides of a borosilicate wafer are coated so as to allow 97% transmission of 1310 nm wavelength, with the reflectivity less than 1% for the 1310 nm spectrum. In one embodiment, the wafer, such as an 8-inch wafer, of borosilicate glass having a 0.25-0.75 mm thickness, is coated with multiple coating layers to achieve the aforementioned 97% transmission and 0.5-1% reflectivity at the 1310 nm wavelength. In such an example embodiment, the wafer may have a surface roughness of less than 130 nm and scratch/dig of 60/40. It will be appreciated that other wafers may be utilized in accordance with the embodiments described herein, and the values presented in the subject application pertain to a variety of example implementations. FIGURE 4 illustrates a reflectivity performance curve and FIGURE 5 illustrates a transmission performance curve of a suitable window **14** fabricated in accordance with the method of FIGURE 3. FIGURES 8A-8B and 9A-9D provide illustrations and tables of varying implementations of the glass window **14**, coatings, and the like, associated with embodiments contemplated in accordance with the subject disclosure. FIGURE 12 provides an illustration of a functional block diagram explaining the fabrication process of FIGURE 3 with respect to the production of windows **40** from the wafer. In accordance with one embodiment, the wafer undergoes multiple layers of coating, including a final layer of SiO₂. While referenced as pertaining to the 1310 nm spectrum, the coatings applied to the wafer may be varied in accordance with the selected spectrum, e.g., coatings specific to 1200 nm to 1610 nm.

[0043] At **304**, a pattern is formed on the wafer corresponding to the pattern of deposition for a seal ring **38**. At **306**, a metallization seal ring **38** (as illustrated in FIGURE 2) is then thin film coated on the wafer in accordance with the deposition pattern referenced above. In accordance with one embodiment, the metallization seal ring **38** on the window **14** is comprised of a preselected combination of metals, e.g., chromium, nickel, and gold are formed onto the window **14** prior to separation of the window **14** from the manufacturing wafer. As shown in FIGURE 2, the metallization seal ring **38** includes a seed layer **39A**, an intermediate layer **39B**, and a top layer **39C**. For example, the seed layer **39A** may comprise 0.04 μm MIN chromium, the intermediate layer **39B** may comprise 0.7 μm $\pm$ 0.2 μm nickel and the top layer **39C** may comprise 0.04 μm MIN gold.

[0044] It will be appreciated that as discussed elsewhere herein, the seal ring **38** is slightly larger than the window preform **40** (shown in FIGURE 6) so as to allow full wetting during soldering of the window **14** to the assembly **10** using the pre-form **40**. It should also be appreciated that the entire surface of the wafer is AR coated, resulting in the metallization seal ring **38** being deposited on top of the coating, thereby allowing faster mass production of multiple windows **14**. The present embodiments therefore prevent the inherent loss of windows **14** resulting from AR coating extending onto portions of the glass on which a metallization ring was to be deposited. The individual windows **14** are then separated from the wafer via dicing thereof at **308** for attachment to the cap assembly **10** as discussed below.

[0045] Interposed between the window **14** and the back side **22** of the housing **11** is a solder pre-form **40**, which allows the formation of a hermetic seal between the glass of the window **14** and the housing **11**. The solder pre-form **40** is suitably constructed to bond to the metallization ring **38** of the window **14**.

[0046] The cap assembly of claim **11**, further comprising a solder pre-form **40** between the back side **22** and the window **14**, the pre-form **40** configured to attach the window **14** to back side **22** via the metallization seal ring **38** deposited on the window **14** to form an hermetic seal there-between. An example of the solder pre-form **40** is depicted in FIGURE 6. In accordance with such an example embodiment, the solder pre-form **40** is comprised of a gold and tin, with a melting temperature of 280°C. The relative composition of elements in the pre-form **40** may be 80% gold and 20% tin. It will be appreciated that the eutectic solder of 80%Au20%Sn has a single melting temperature of 280°C. The solder pre-form **40** may be formed via layering of the gold and tin, as will be appreciated.

[0047] As illustrated in FIGURE 6, the shape of the solder pre-form **40** is similar to and approximately matches the shape of the metallization seal ring **38** on the window **40**. That is, the solder pre-form **40** may be slightly smaller than the metallization seal ring **38** so as to allow full wetting of the solder pre-form **40** between the window **14** and the back side **22** of the housing **11**, while also preventing any obstruction of the opening **24** through the coated glass window **14**. It will be appreciated that the soldering of the window **14** to the back side **22** of the housing **11** may be accomplished via application of 280°C with the solder pre-form **40** positioned there-between as shown in FIGURE 1A. According to one

embodiment, the solder pre-form **40** may be stamped to meet the metallization seal ring **38** on the window **40**. The solder pre-form **40** may be used to seal the glass window **40** to the assembly **10** in an inert environment, e.g., nitrogen, nitrogen-hydrogen, etc. The solder pre-form **40** may be attached in such an environment without the addition of flux. A descriptive drawing of this attachment is illustrated in FIGURE 10.

[0048] After the hermetic attachment of the window **14** to the back side **22** of the housing **11**, the cap assembly **10** may be attached to a silicon substrate (not shown) on which are various optical communication components, e.g., transceivers, receivers, microprocessors, control logic, etc. In one embodiment, the cap assembly **10** may be attached to the silicon substrate using a second pre-form **42**, illustrated in FIGURE 7. As shown in FIGURE 7, the second pre-form **42** is capable of attachment to the top of the sides **16-22** and legs **26-28**. Use of the second pre-form **42** thereby enables the joining of the assembly **10** to a suitable substrate, thereby providing a hermetic sealing of the cavity **12** inside the housing **11**. Such hermetic sealing may enable the protection of the internal components located in the housing **11** from dust, dirt, air (if vacuum or inert gas filled), light moisture, and the like.

[0049] In one embodiment, the second solder pre-form **42** is comprised of various metals having a melting temperature less than that of the first solder pre-form **40**, so that deformation or leakage of the seal of the window **14** to the housing **11** does not occur upon attachment of the assembly **10** to the silicon substrate. It will be appreciated that while described with respect to attachment to a silicon substrate, other types of substrates may also be used in the instant disclosure, e.g., a metal substrate similar in composition to the plated housing **11**, for example, may be used to hermetically seal the housing **11**. For example, the second solder pre-form **42** may also be a combination of gold and tin, but varying in composition to have a melting temperature less than that of the first solder pre-form **40**. In such an example implementation, the composition of the second solder pre-form **42** may comprise 90% tin and 10% gold, with a melting temperature of 217°C. It will be appreciated that variations on the relative percentages of gold and tin, or metals with similar properties, may be substituted in accordance with the embodiments discussed herein.

[0050] TABLE 1, presented below, provides various solders, their respective melting points, and compositions.

WAM Solder	Nominal Composition Wt. %	Liquidus C F		Solidus C F		Density (g/cc)	Electrical Conductivity (% of IACS)	Thermal Conductivity (W/m ² /C)	Thermal Coefficient of Expansion (Micro in/in/C) (25C)	Tensile Strength (psi)
WVS96*	30Pb, 18Sn, Bi52	96	205	96	205	9.58	3.2	15	34.3	3200
WVS118	49Sn, 52In	118	244	118	244	7.30	11.7	34	20.0	1720
WVS143	3Ag, 97In	143	290	143	290	7.38	4.5	73	22.0	800
WVS145	58Sn, 42In	145	493	118	244	7.30	11.2	33	31.0	5900
WVS149*	5Ag, 15Pb, 80In	149	300	149	288	7.85	8.7	43	28.3	2550
WVS157	100In	157	315	157	315	7.31	5.6	82	24.8	575
WVS174*	30Pb, 70In	174	347	165	329	8.19	8.8	38	28.0	3450
WVS179†	2Ag, 36Pb, 62Sn	179	354	179	354	8.41	1.9	42	27.0	6380
WVS181*	37.5Pb, 37.5Sn, 25In	181	258	134	273	8.42	7.8	23	23.0	5260
WVS183*	37Pb, 63Sn	183	361	183	361	8.34	11.8	51	25.0	7500
WVS185*	40Pb, 60In	185	358	173	343	8.52	7.0	29	27.0	4150
WVS186*	30Pb, 70Sn	186	367	183	361	8.17	12.5	53	27.0	7800
WVS187	2.8Ag, 77.2Sn, 20In	187	389	175	347	7.25	9.8	54	28.3	6800
WVS188*	40Pb, 60Sn	188	376	183	361	8.50	11.5	49	21.6	7610
WVS199*	20Pb, 80Sn	199	39	183	361	7.85	13.8	59	24.5	5800
WVS200*	45Pb, 55Sn	200	392	183	361	8.68	11.2	48	22.6	6000
WVS203*	15Pb, 85Sn	203	401	183	361	7.70	13.6	58	23.3	5300
WVS209*	50Pb, 50In	209	410	184	363	8.86	6.0	22	27.0	4675
WVS212*	50Pb, 50Sn	212	414	183	361	8.87	10.9	47	23.6	6000
WVS213*	10Pb, 90Sn	213	415	183	361	7.55	13.1	56	26.5	3300
WVS217	10Au, 90Sn	217	433	217	433	3.73	10.2	38	14.0	35000
WVS221	3.5Ag, 96.5Sn	221	430	221	430	7.36	16.0	33	30.2	5620
WVS223*	60Pb, 40In	223	437	205	401	9.30	5.2	19	36.2	5800
WVS226	3.5Ag, 95Sn, 1.5Sn	226	439	218	424	7.37	11.9	29	18.0	7300
WVS226A	2.5Ag, 97.5Sn	226	439	226	430	7.34	11.2	38	19.5	8300
WVS227	100Sn	232	450	232	450	7.28	15.6	73	23.5	1900
WVS235	89Sn, 10Bi	235	455	235	455	7.27	32.3	29	32.0	2830
WVS239*	60Pb, 40Sn	238	460	183	361	9.28	10.1	44	24.7	5400
WVS238A	97Sn, 2Bi	238	460	232	450	9.28	13.3	38	23.0	4080
WVS240	95Sn, 5Bi	240	464	232	450	7.25	11.9	28	27.0	5460
WVS243*	63.2Pb, 35.5Sn, 1.3Bi	243	469	185	365	9.39	9.5	41	21.0	2900
WVS257*	75Pb, 30Sn	257	495	183	361	9.66	9.3	41	25.6	5000
WVS264*	75Pb, 25Sn	264	500	240	464	9.97	4.6	18	28.0	5450
WVS280*	80Pb, 20Sn	280	536	183	361	10.04	8.7	37	26.5	4800
WVS280A	81Pb, 19In	280	536	270	518	10.37	4.5	17	27.0	5350
WVS280B	80Au, 20Sn	280	536	280	536	14.51	7.7	57	15.9	40000
WVS286*	88Pb, 8Bi, 4Sn, 1In, 1Ag	286	547	268	514	10.91	5.6	33	22.4	5317
WVS288*	85Pb, 15Sn	288	550	183	361	10.48	8.5	37	27.2	4600
WVS290*	2Ag, 88Pb, 10Sn	290	570	238	513	10.75	8.5	27	29.1	3260
WVS292*	5Ag, 90Pb, 5Sn	292	558	292	558	11.00	7.7	26	26.0	5100
WVS295*	95Pb, 5Sn	295	563	352	486	10.94	6.2	27	27.0	4200
WVS296*	2.5Ag, 92.5Pb, 1Sn	296	565	287	549	11.02	7.6	26	24.0	3500
WVS300*	2.5Ag, 92.5Pb, 5In	300	572	300	572	11.02	5.5	25	25.3	4580
WVS303*	90Pb, 10Sn	302	576	275	527	10.50	8.2	36	27.9	4400
WVS303†	2.5Ag, 97.5Pb	303	577	303	577	11.33	7.5	26	23.0	5900
WVS304*	2.5Ag, 95.5Pb, 2Sn	304	579	299	570	11.20	7.6	26	23.0	3400
WVS305	78Au, 22Sn	305	581	280	536	14.81	2.7	57	15.9	40000
WVS309*	1.5Ag, 97.5Pb, 1Sn	309	589	309	585	11.28	6.0	23	30.4	4420
WVS310*	5Ag, 90Pb, 5In	310	590	288	554	11.00	8.4	29	24.0	4500
WVS341*	95Pb, 5In	314	597	300	572	11.04	5.1	21	27.0	4350
WVS314A*	85Pb, 15Sn	314	598	310	590	10.80	8.1	32	38.4	4000
WVS327*	100Pb	327	621	327	621	11.35	8.4	15	23.3	2750
WVS361	88Au, 12Ge	361	682	361	682	14.67	11.4	44	13.4	26800
WVS363	98.5Au, 1.5Sn	363	683	363	685	15.70	46.4	27	12.3	37000
WVS487	81Au, 19In	487	909	487	909	14.72	8.4	28	14.7	33700

*Contains Lead † Lead Free Solders

TABLE 1

[0051] It will be appreciated the solders presented in TABLE 1 may be utilized for either the first pre-form 40 or the second pre-form 42 in accordance with the type of coating on the window 14, the plating on the assembly 10, the type of substrate (not shown)

to which the cap assembly **10** will be attached, or combinations thereof. Accordingly, different melting temperatures of the pre-forms **40** and **42** may be needed based upon the type of AR coating (so as not to damage the coating). Similarly, variations as to the composition of the metallization seal ring **38** may be necessitated to accommodate changes in make-up of the composition of the pre-form **40** and/or the assembly **10**.

[0052] In accordance with one embodiment, the hermetically sealable cap assembly for use in open air optical communications. Current radio wave communications have limitations on the speed of data transfer without causing increased harm to humans. In such an implementation, the glass window of the cap assembly is coated with a single wavelength anti-reflective coating corresponding to laser data transmittal. The references above to the 1310 nm wavelength is intended for example purposes only, as such a wavelength corresponds to the wavelength of light utilized in fiber-optic cables to transmit data between sites, which light may be generated by a Gallium-Arsinide semiconductor laser diode. Depending upon the coherent technology used and bit rates desired, other wavelengths of light may be utilized. In such instances, the coating of the window may be modified to reflect the common peak wavelengths (780 nm, 850 nm, 1550 nm, 1625 nm, etc.) corresponding to the light source and detector technology implemented. Accordingly, it will be appreciated that the subject application may be adapted in accordance with the intended communication system.

[0053] It will be appreciated that variants of the above-disclosed and other features and functions, or alternatives thereof, may be combined into many other different systems or applications. Various presently unforeseen or unanticipated alternatives, modifications, variations or improvements therein may be subsequently made by those skilled in the art which are also intended to be encompassed by the following claims.

WHAT IS CLAIMED IS:

1. A cap assembly, comprising:
a housing, including:
a front side perpendicular from a bottom side,
opposing parallel first and second sides perpendicular from the bottom side, and
a back side disposed perpendicularly between the first side and the second side offset from respective ends of the first side and the second side opposite the front side,
wherein the back side includes an opening there-through and a three-sided ledge formed along an interior of the first side leg, an exterior of the back side, and an interior of the second side leg; and
a window configured to contact the three-sided ledge of the back side, the glass panel covering the opening there-through.
2. The cap assembly of claim 1, wherein the housing is comprised of an iron-nickel-cobalt alloy.
3. The cap assembly of claim 2, wherein the housing is plated with nickel and gold.
4. The cap assembly of claim 3, wherein the window is a multi-coated borosilicate glass panel having a thickness between 0.4 mm and 0.6 mm.
5. The cap assembly of claim 4, wherein the window includes a metallization seal ring disposed along a perimeter of the window on a side of the window contacting the back side of the housing.
6. The cap assembly of claim 5, wherein the metallization seal ring is formed on the window in accordance with a deposition pattern along the perimeter of the window.
7. The cap assembly of claim 6, wherein the metallization seal ring comprises at least three layers.

8. The cap assembly of claim 7, wherein the at least three layers include a seed layer of chromium, an intermediate layer of nickel and a top layer of gold.

9. The cap assembly of claim 8, further comprising a first solder pre-form between the back side and the window, the first pre-form configured to attach the window to back side forming an hermetic seal there-between.

10. The cap assembly of claim 9, further comprising a second solder pre-form pre-form between a top of the housing and a silicon substrate.

11. The cap assembly of claim 10, wherein the first solder pre-form and the second solder pre-forms are comprised of gold and tin, and wherein the first solder pre-form includes a greater percentage of tin than the second solder pre-form

12. The cap assembly of claim 11, wherein the first solder pre-form has a melting temperature higher than a melting temperature of the second solder pre-form.

13. A method of forming at least one window for attachment to a metal cap assembly, comprising:

coating each side of an associated wafer;

forming a pattern on one side of the associated wafer;

layering a metallization seal ring onto the pattern; and

dicing the wafer in accordance with the pattern to form the at least one window, wherein the pattern is formed around the perimeter of the at least one window.

14. The method according to claim 13, wherein layering the metallization seal ring onto the pattern further comprises layering a seed layer, an intermediate layer and a top layer onto the one pattern.

15. The method according to claim 14, wherein the seed layer comprises chromium, the intermediate layer comprises nickel, and the top layer comprises gold.

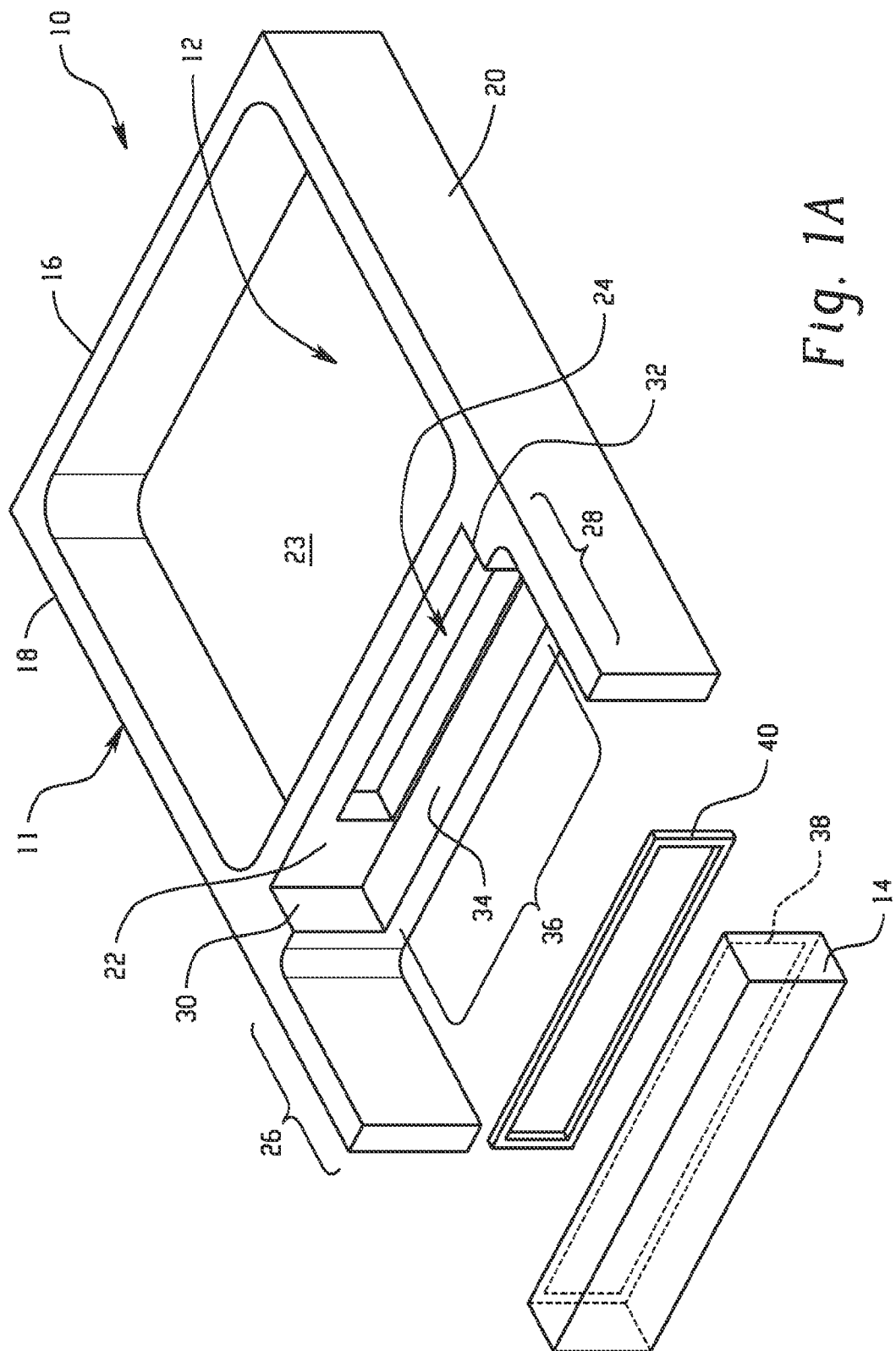
16. The method according to claim 15, wherein attachment of the at least one window to the cap assembly comprises forming a hermetic seal between the at least one window and a back side of the housing using a first solder pre-form inserted therebetween.

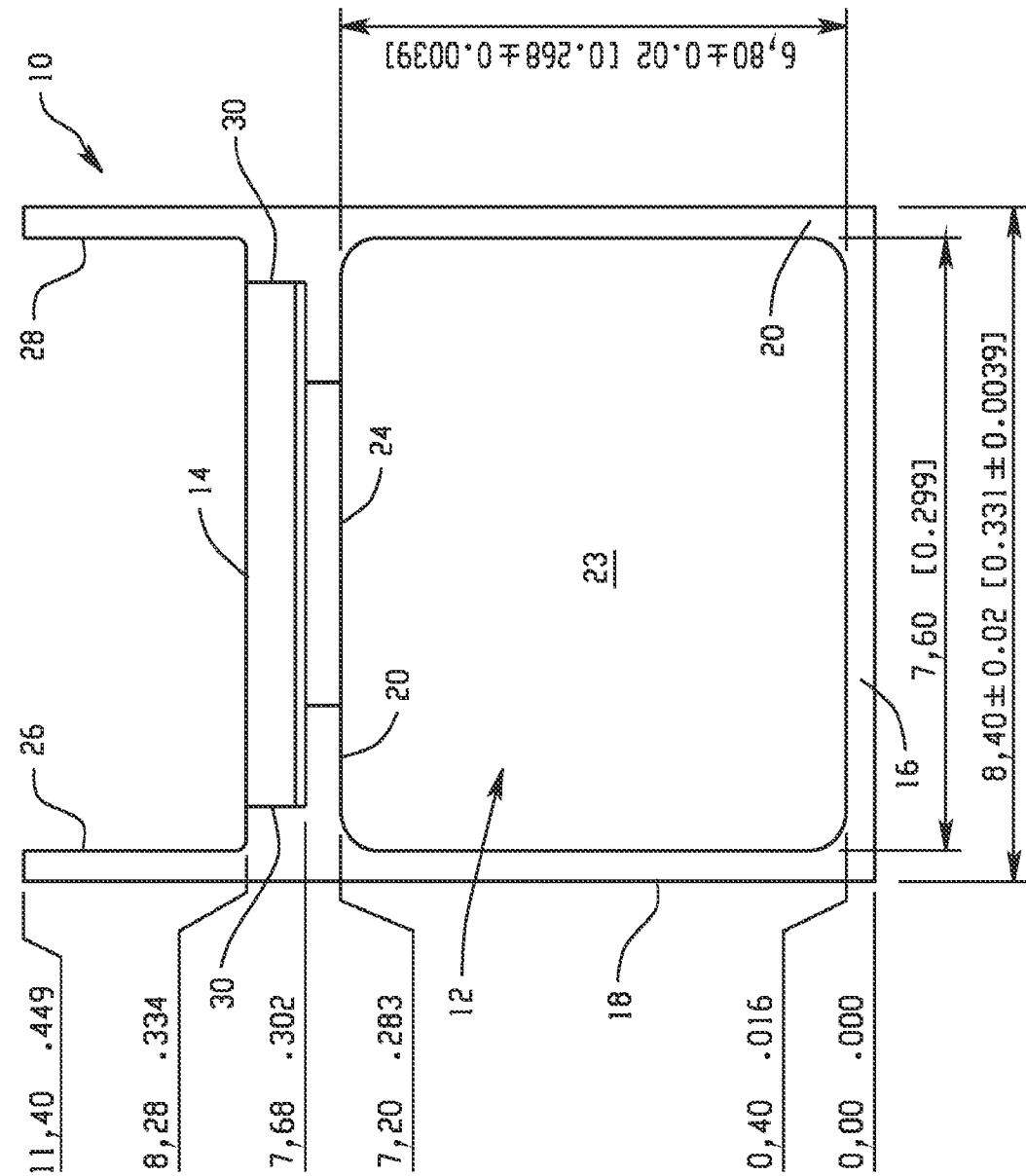
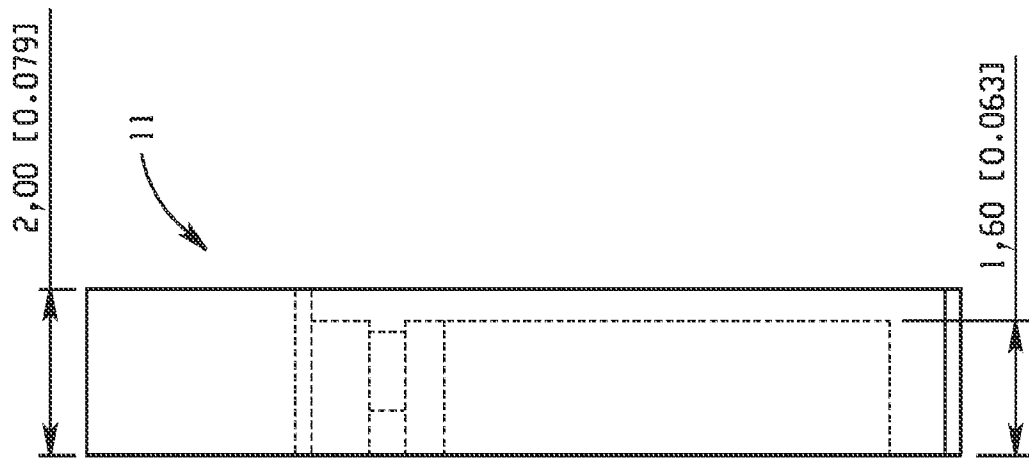
17. A solder pre-form for hermetically sealing a multi-coated glass panel having a metallization seal ring layered around a perimeter of one side thereof to a cap assembly including a plated metal housing, the pre-form comprising at least one layer of gold and at least one layer of tin, wherein the pre-form is sized to affix to the metallization seal ring.

18. The solder pre-form of claim 17, wherein the metallization seal ring comprises a seed layer of chromium, an intermediate layer of nickel, and a top layer of gold.

19. The solder pre-form of claim 18, wherein the multi-coated glass panel is comprised of borosilicate glass.

20. The solder pre-form of claim 19, wherein the housing is comprised of an iron-nickel-cobalt alloy, and wherein the housing is plated with a layer of nickel and a layer of gold.





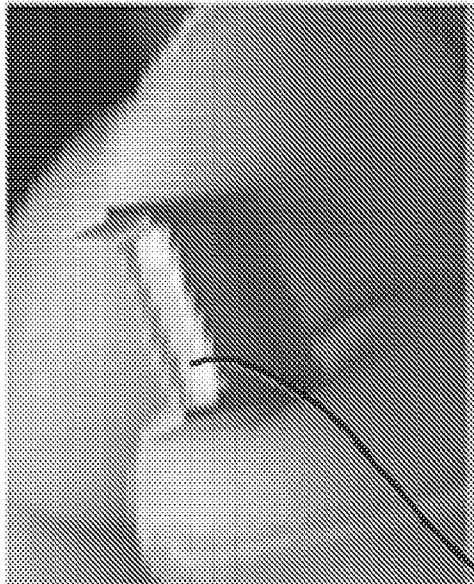


Fig. 1F

14

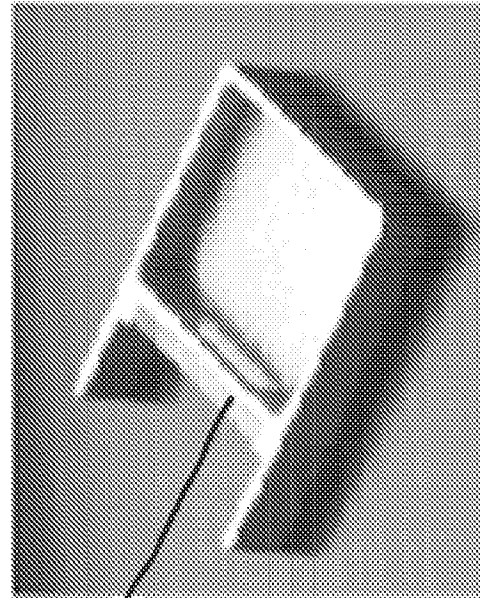


Fig. 1G

14

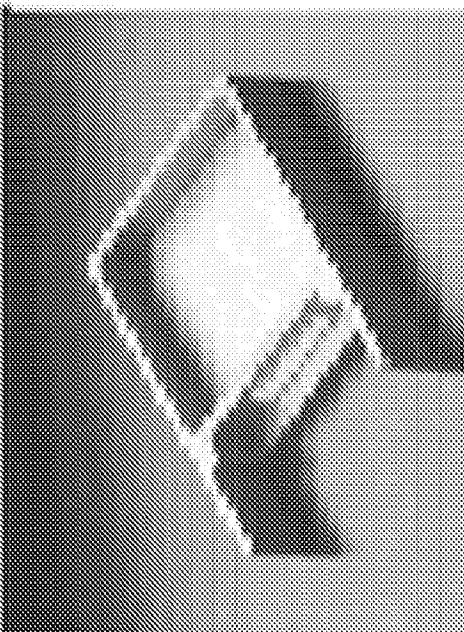


Fig. 1D

14

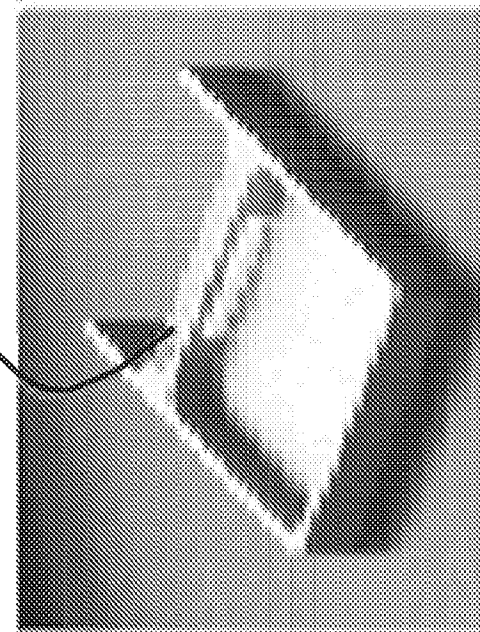


Fig. 1E

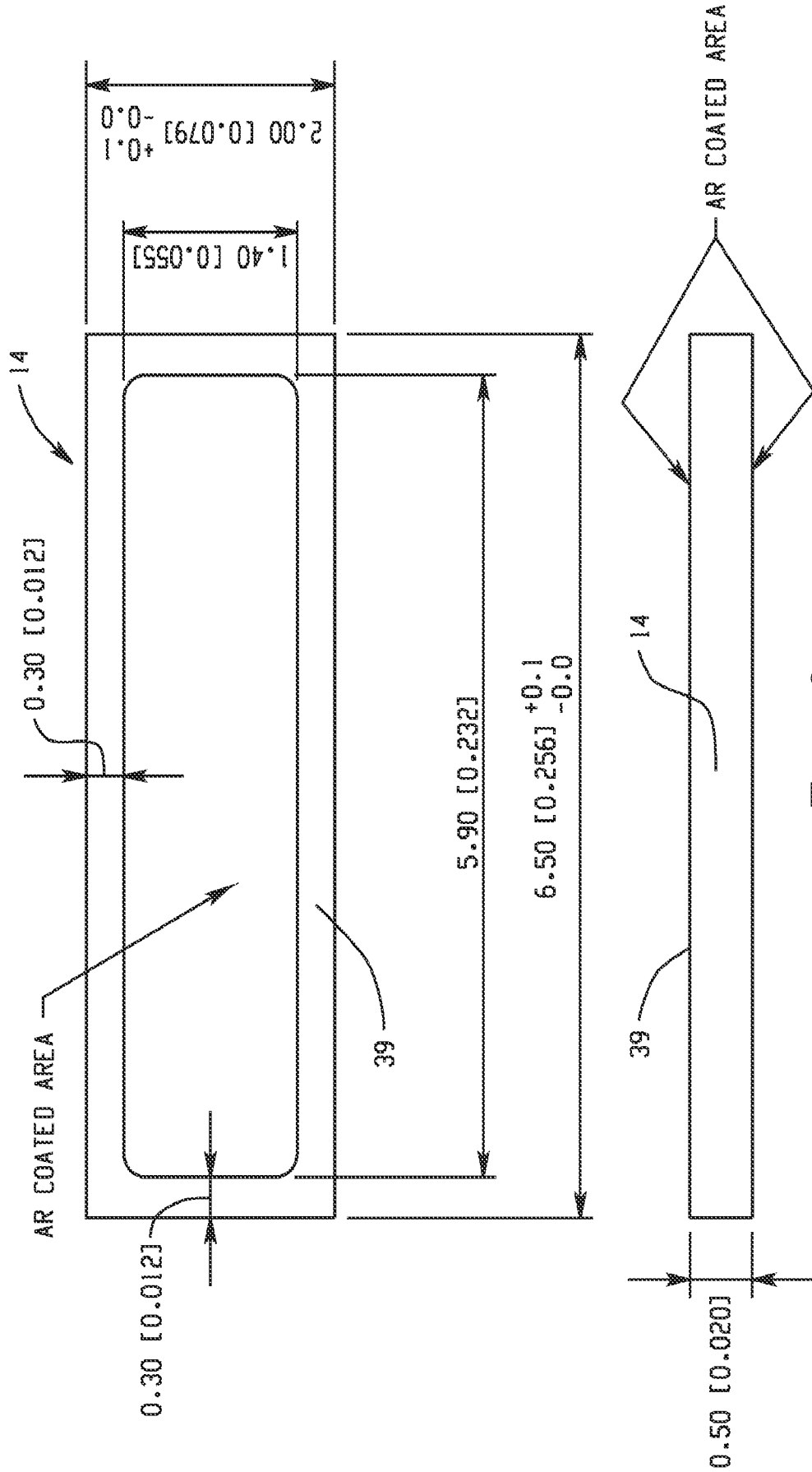
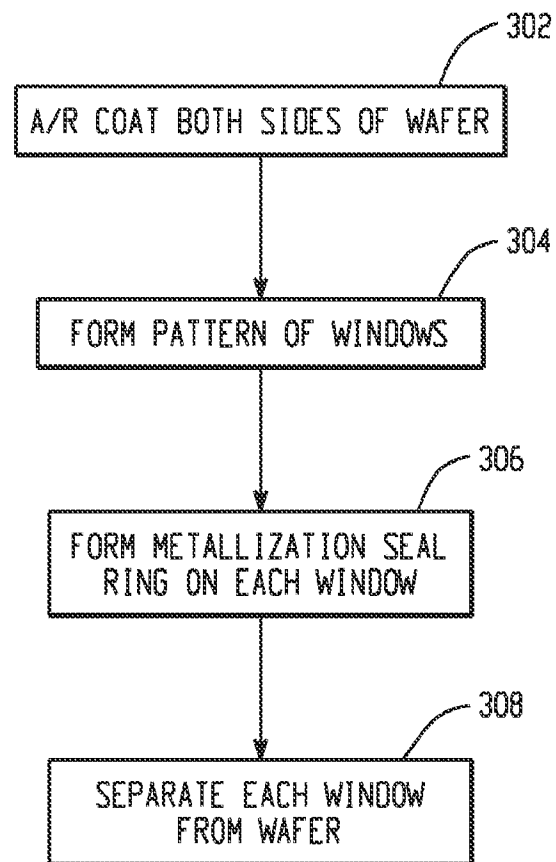


Fig. 2

5/18

*Fig. 3*

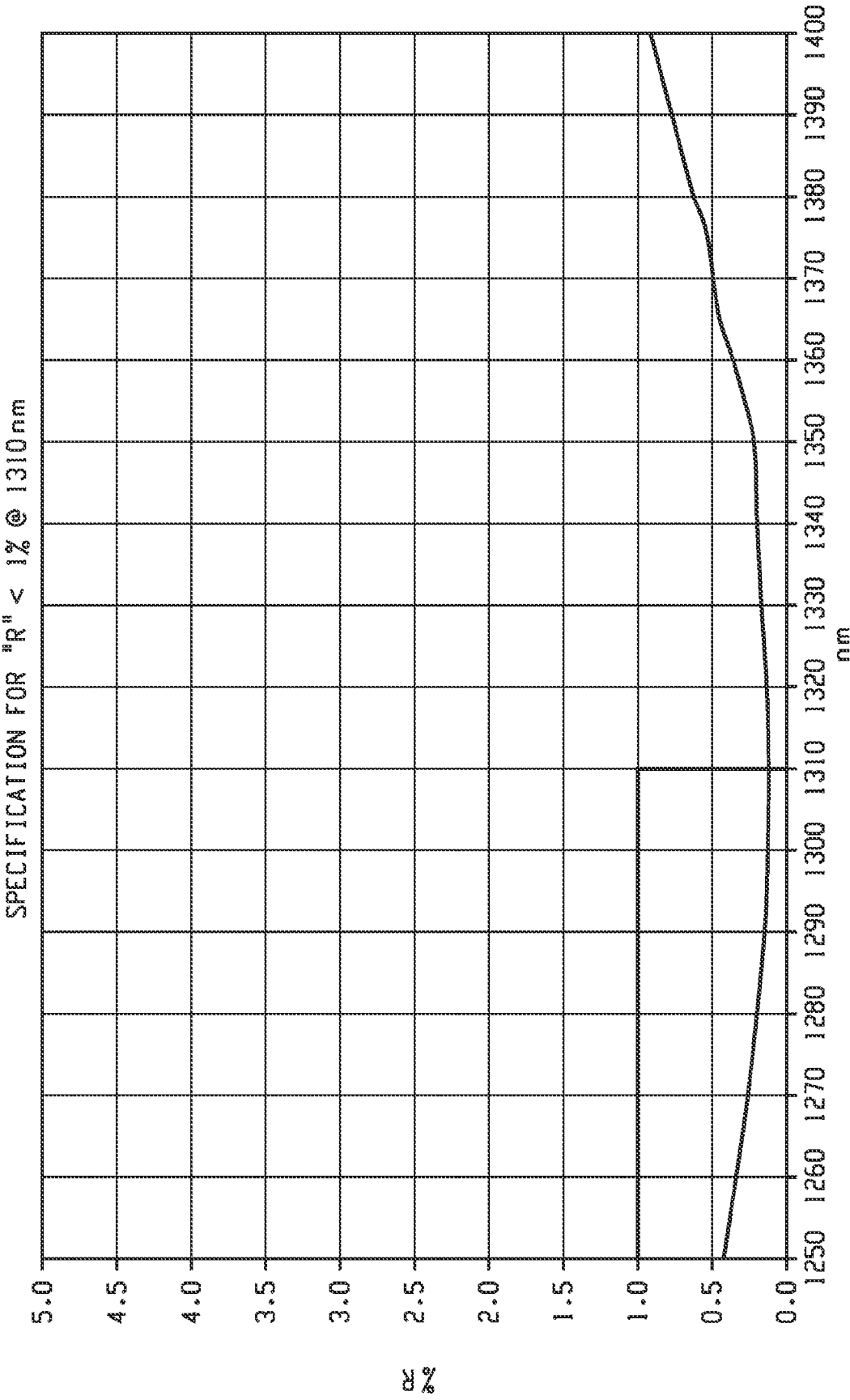


Fig. 4

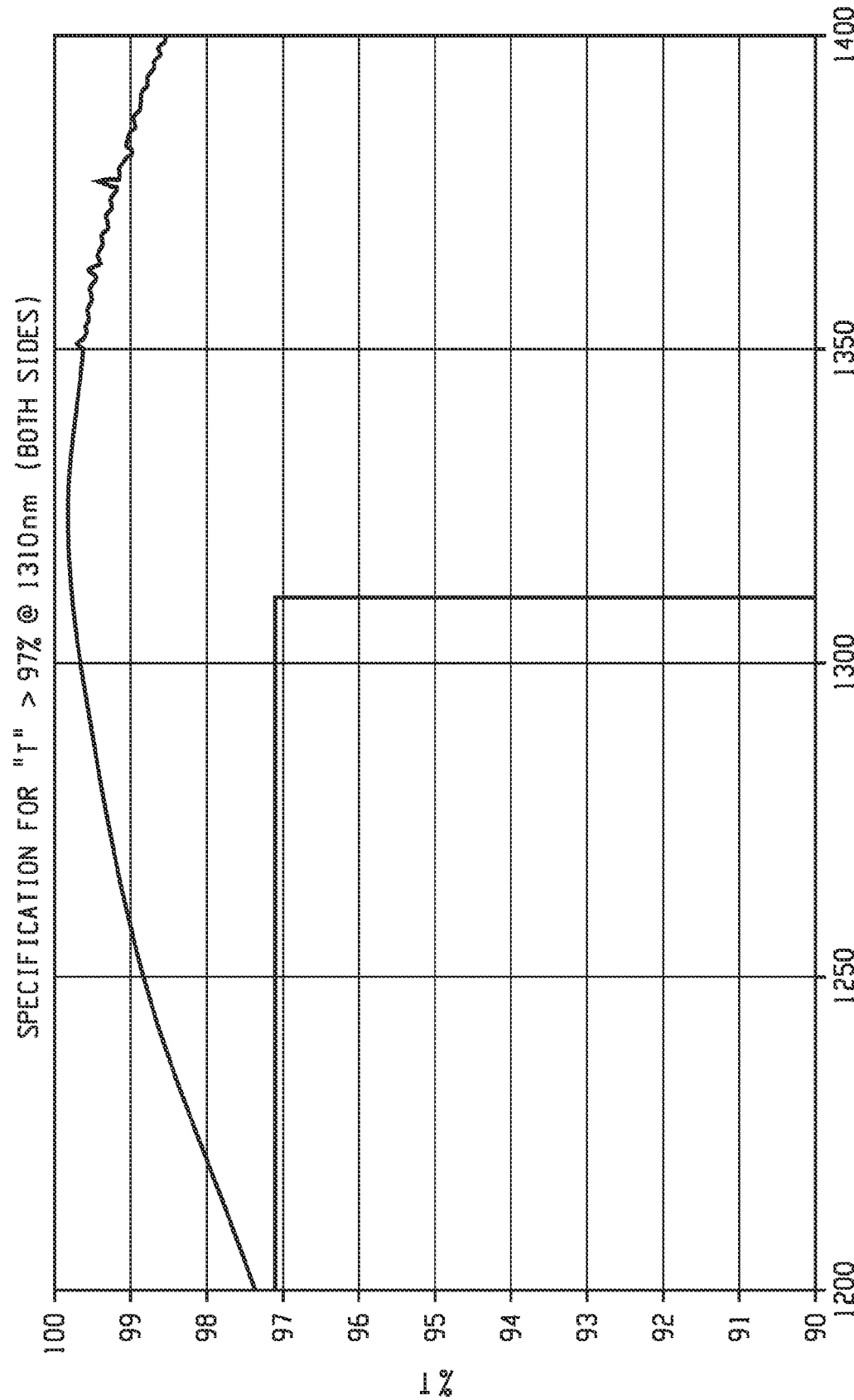


Fig. 5

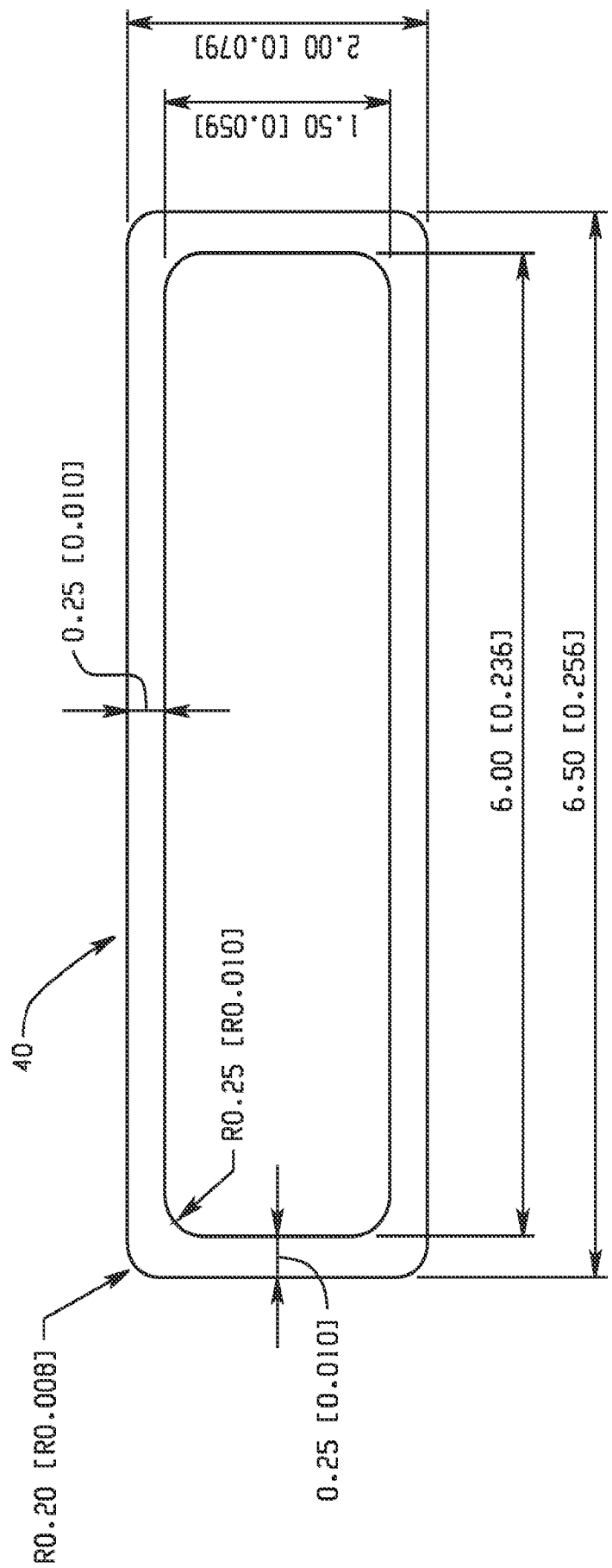


Fig. 6

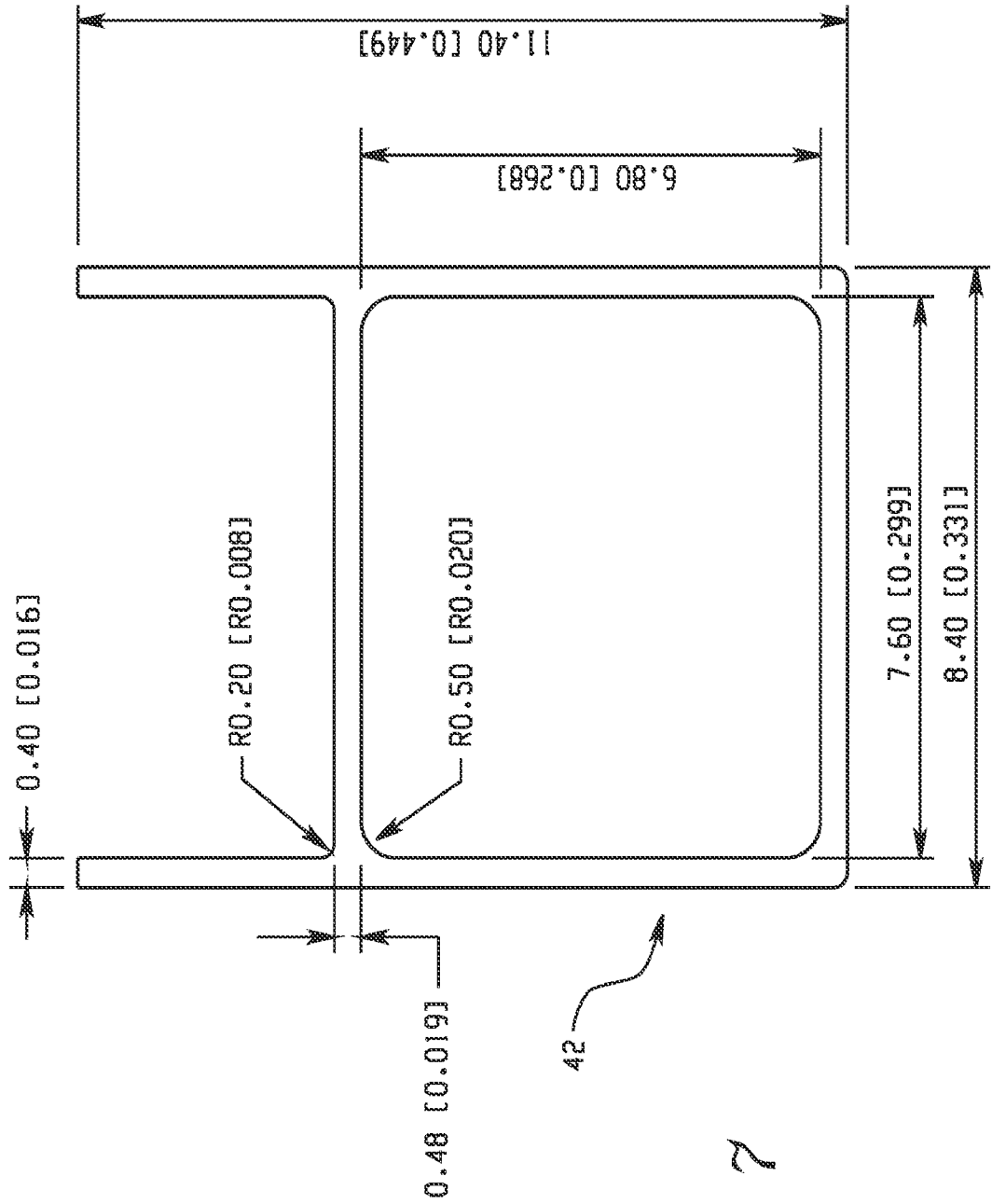


Fig. 7

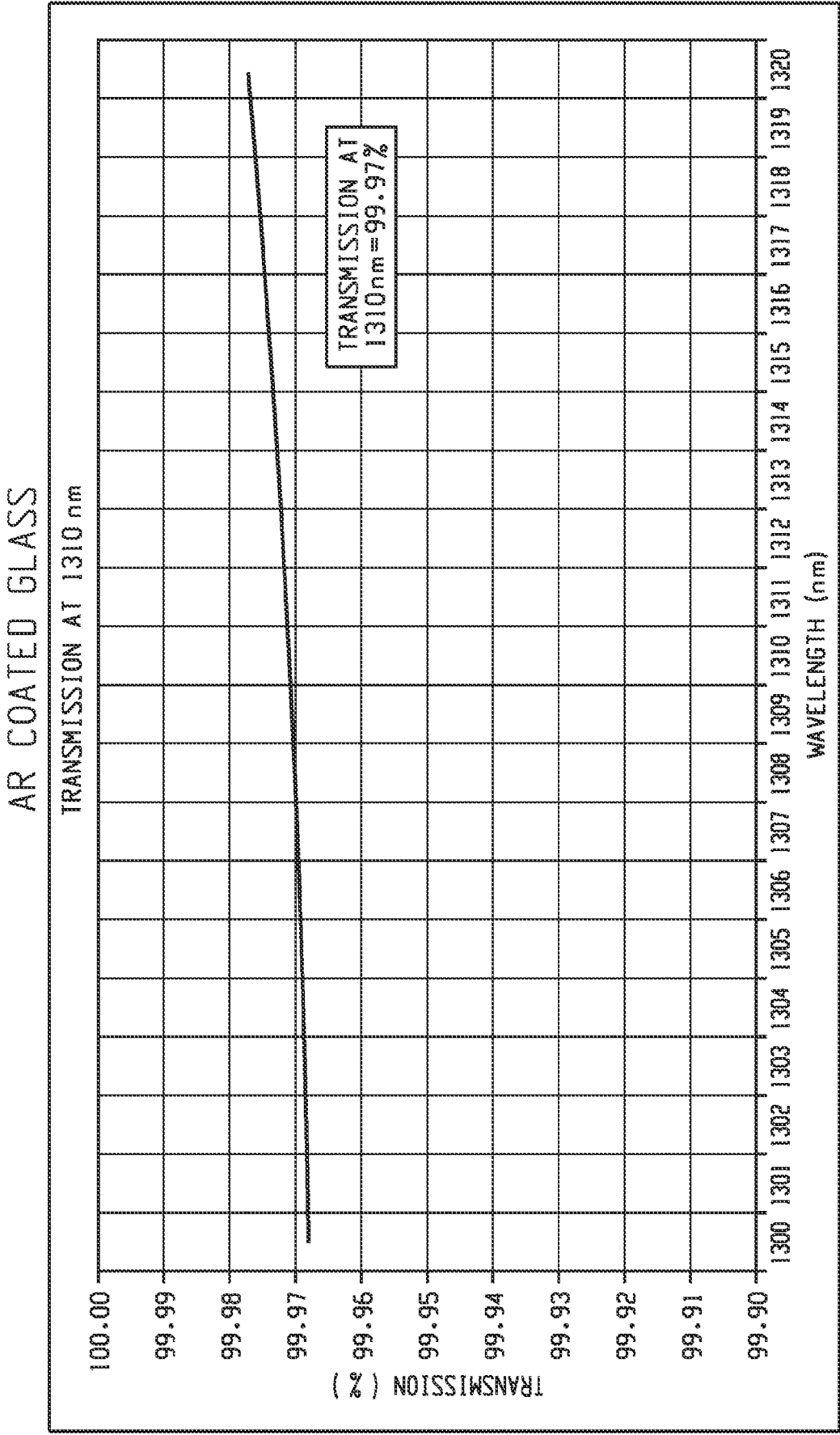


Fig. 8A

11/18

AR COAT DATA

AR SIDE 1 & 2 @ 0 DEG		
WAVELENGTH (nm)	%R	%T
1300	0.03215	99.96785
1301	0.03194	99.96806
1302	0.03170	99.96830
1303	0.03142	99.96857
1304	0.03112	99.96888
1305	0.03079	99.96921
1306	0.03043	99.96957
1307	0.03005	99.96995
1308	0.02964	99.97036
1309	0.02920	99.97079
1310	0.02874	99.97125
1311	0.02826	99.97173
1312	0.02776	99.97224
1313	0.02723	99.97277
1314	0.02668	99.97332
1315	0.02611	99.97388
1316	0.02553	99.97447
1317	0.02492	99.97508
1318	0.02430	99.97570
1319	0.02367	99.97633
1320	0.02302	99.97698

Fig. 8B

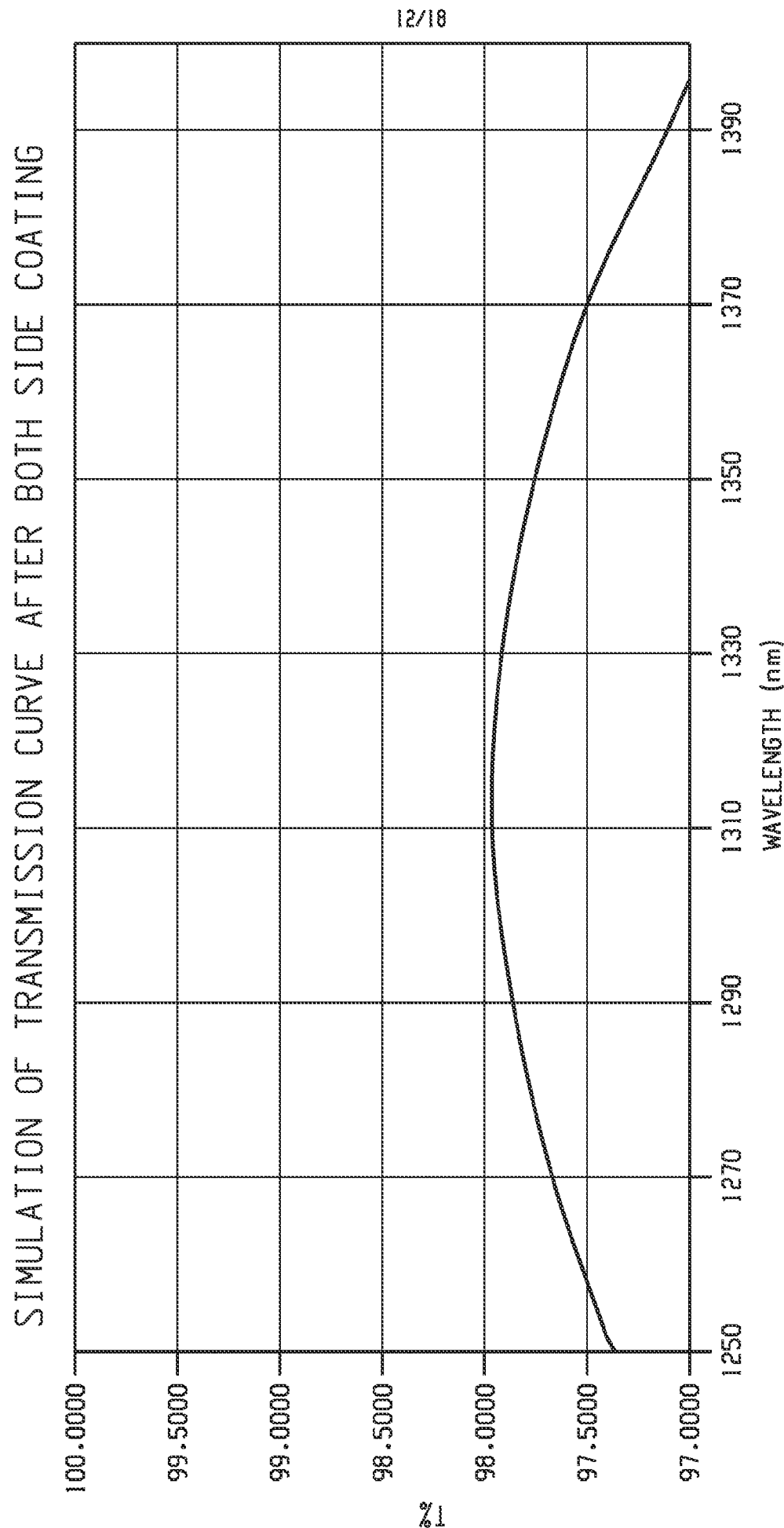


Fig. 9A

bcdefghijklmnopqrstuvwxyz*li*

GLASS DATA

REFRACTIVE INDICES		CHEMICAL PROPERTIES	
	λ (nm)		GRADE
n_F	706.5	RC(S)	1
$n_{C'}$	656.3	RA(S)	1
$n_{C''}$	643.8	DW	3
n_{He-Ne}	632.8	DA	1
n_D	589.3		
n_d	587.6		
n_e	546.1		
n_F	486.1		
$n_{F'}$	480.0		
n_g	435.8		
n_h	404.7		
n_I	365.0		

THERMAL PROPERTIES	
T_g ($^{\circ}C$)	569
T_S ($^{\circ}C$)	637
$T_{10}^{14.5}$ ($^{\circ}C$)	511
T_{10}^{13} ($^{\circ}C$)	547
$\alpha_{20/120^{\circ}C}$ ($10^{-7}/K$)	71.72
$\alpha_{20/300^{\circ}C}$ ($10^{-7}/K$)	82.65

$n_d = 1.51680$	$vd = 64.2$	$n_F - n_C = 0.008050$
$n_e = 1.51872$	$ve = 64$	$n_{F'} - n_{C'} = 0.008105$

Fig. 9B

GLASS DATA

CONSTANTS OF DISPERSION FORMULA			MECHANICAL PROPERTIES	
A ₀	2.2702566		H _K (10 ⁷ Pa)	595
A ₁	-9.19881011 X 10 ⁻³		F _A	1
A ₂	1.16097061 X 10 ⁻²		E (10 ⁷ Pa)	7920
A ₃	-7.61239111 X 10 ⁻⁵		G (10 ⁷ Pa)	3270
A ₄	2.85587271 X 10 ⁻⁵		μ	0.211
A ₅	-1.25664861 X 10 ⁻⁵			
RELATIVE PARTIAL DISPERSION			STRESS-OPTICAL COEFFICIENT	
P _{d,c}	0.3081	P' _{d,c}	B (10 ⁻¹² /Pa)	2.7
P _{c,d}	0.2385	P' _{c,d}		
P _{g,F}	0.5342	P' _{g,F}		
DEVIATION OF RELATIVE PARTIAL DISPERSIONS ΔP FROM THE "NORMAL LINE"			COLORATION CODE	
ΔP _{F,c}	-0.0013		λ ₈₀ /λ ₅	33/29
ΔP _{g,F}	-0.0028			
			OTHER PROPERTIES	
			P (g/cm ³)	2.49

Fig. 9C

15/18

GLASS DATA

INTERNAL TRANSMITTANCE		
λ (nm)	$\tau_{5\text{ nm}}$	$\tau_{10\text{ nm}}$
2400	0.860	0.740
2200	0.930	0.860
2000	0.960	0.922
1800	0.985	0.970
1600	0.990	0.980
1400	0.995	0.990
1200	0.988	0.996
1060	0.988	0.996
1000	0.999	0.997
950	0.999	0.997
900	0.999	0.998
850	0.999	0.998
800	0.999	0.999
700	0.999	0.999
650	0.999	0.998
600	0.999	0.999
550	0.999	0.999
500	0.999	0.998
480	0.999	0.998
460	0.999	0.998
440	0.999	0.997
420	0.999	0.998
400	0.999	0.998
390	0.998	0.997
380	0.997	0.993
370	0.997	0.993
360	0.994	0.988
350	0.989	0.977
340	0.977	0.954
330	0.950	0.910

Fig. 9D

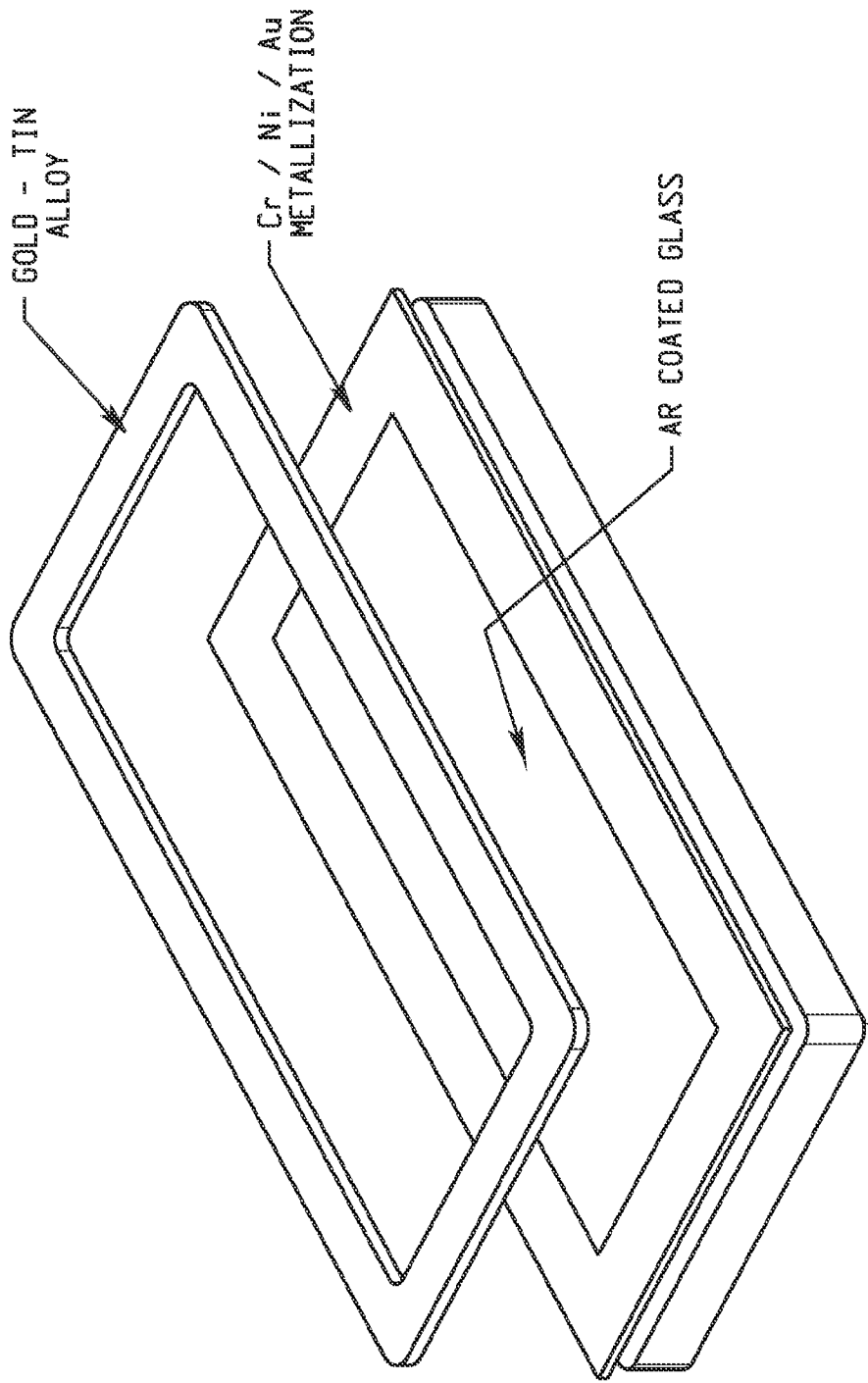


Fig. 10

17/18

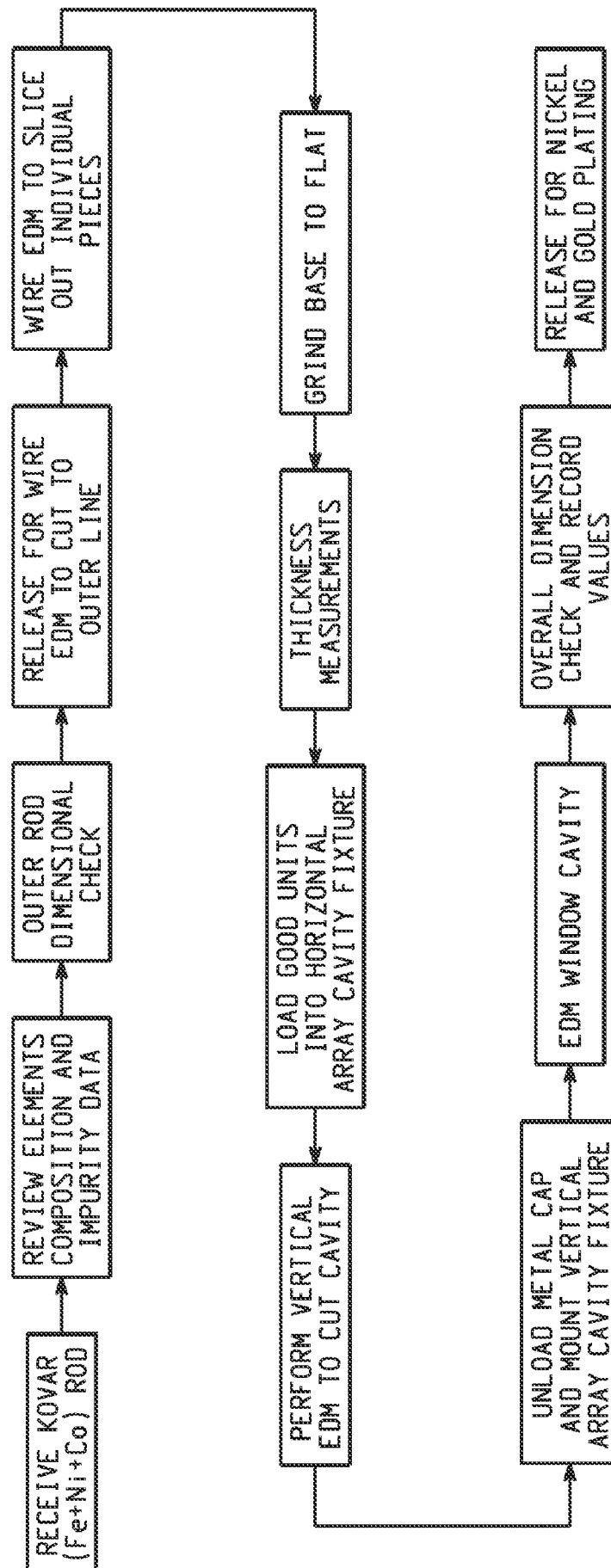


Fig. 11

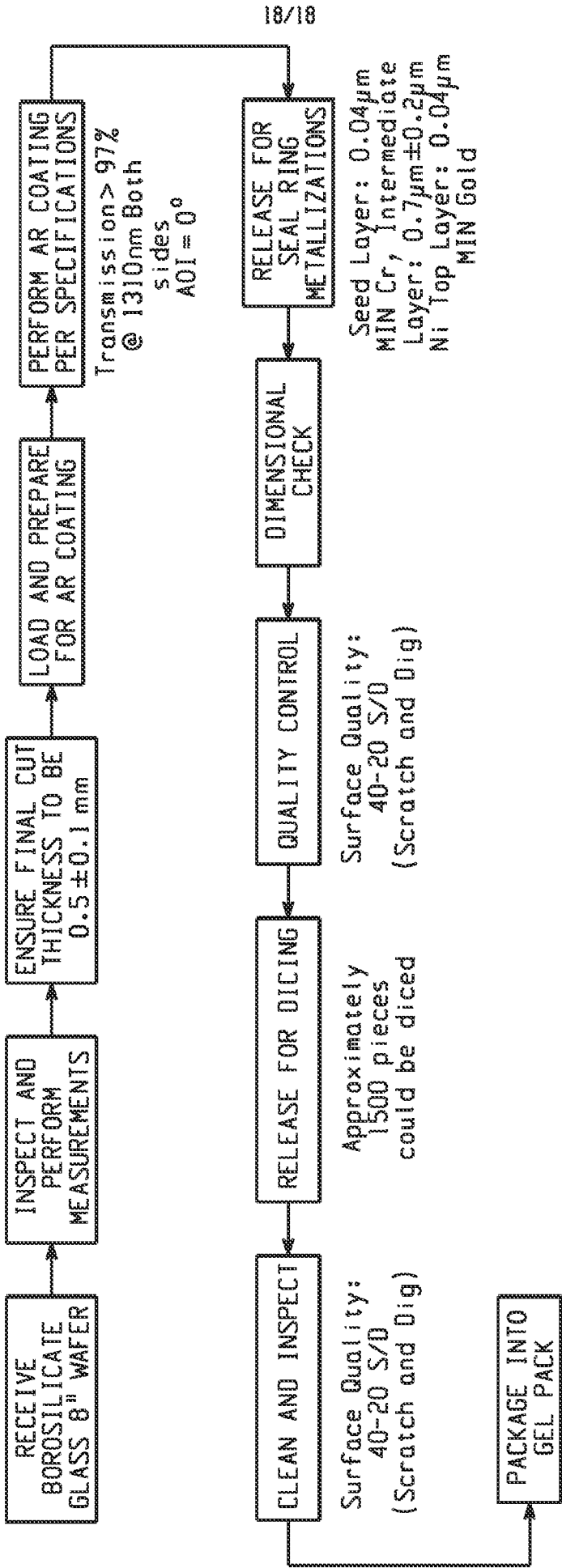


Fig. 12