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Has received an application for a patent for a new and useful invention. The title and description of the invention are enclosed. The requirements of law have been complied with, and it has been determined that a patent on the invention shall be granted under the law.

Therefore, this

United States Patent

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David J. Kyfos

Director of the United States Patent and Trademark Office



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(12) United States Patent
Sawai et al.**(10) Patent No.: US 8,071,183 B2**
(45) Date of Patent: Dec. 6, 2011**(54) DISPLAY APPARATUS****(75) Inventors:** Yuichi Sawai, Mito (JP); Osamu Shiono, Hitachi (JP); Takashi Namekawa, Hitachi (JP); Takashi Naitou, Funabashi (JP); Mitsuo Hayashibara, Hitachinaka (JP); Yuichi Kijima, Chosei (JP); Shigemi Hirasawa, Chiba (JP); Shunichi Asakura, Inba (JP); Hiroki Yamamoto, Hitachi (JP); Akira Hatori, Chiba (JP)**(73) Assignees:** Hitachi Displays, Ltd., Chiba (JP); Panasonic Liquid Crystal Display Co., Ltd., Hyogo-ken (JP)**(*) Notice:** Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 785 days.**(21) Appl. No.: 11/756,653****(22) Filed: Jun. 1, 2007****(65) Prior Publication Data**

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C03C 8/00 (2006.01)**(52) U.S. Cl.** 428/1.5; 428/1.1; 501/11; 501/14; 501/15; 501/17; 501/21; 501/24**(58) Field of Classification Search** 501/11, 501/14, 15, 17, 21, 24; 428/1.1, 1.5

See application file for complete search history.

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Primary Examiner — Gwendolyn Blackwell**(74) Attorney, Agent, or Firm** — Antonelli, Terry, Stout & Kraus, LLP.**(57) ABSTRACT**

A sealing glass of a low melting point phosphate glass composition contains 15 to 35% of BaO and Sb₂O₃ (in total) and the ratio by weight of BaO to Sb₂O₃ or Sb₂O₃ to BaO is 0.3 or less. Particularly the transition metal is vanadium and the glass contains V₂O₅ of 45 to 60 wt % as vanadium oxide and P₂O₅ of 15 to 30 wt % as phosphorus oxide. The bonding material is a mixture of a filler and a vanadate-phosphate glass that contains V₂O₅ of 45 to 60%, P₂O₅ of 20 to 30%, BaO of 5 to 15%, TeO₂ of 0 to 10%, Sb₂O₃ of 5 to 10%, and WO₃ of 0 to 5%. The particle size of the filler is in the range of 1 to 150 μm and the ratio of filler is 80% by volume or less of the adhesive glass.

16 Claims, 8 Drawing Sheets

TABLE 5-continued

| Number | Particle size of filler (d90) (μm) | Mixing ratio of filler (% by volume) | Particle size of glass bead (μm) | Mixing ratio of glass beads (% by volume) | Breaking stress of bonding material (MPa) |
|--|--|--|--|---|---|
| TASF-8-2 | 180 | 20 | 200 | 0.5 | 27.2 |
| TASF-9-1 | 210 | 20 | 50 | 0.5 | 28.9 |
| TASF-9-2 | 210 | 40 | 50 | 0.5 | 24.6 |
| TASF-10-1 | 300 | 30 | 100 | 0.5 | Not bonded |
| TASF-10-2 | 300 | 60 | 100 | 0.5 | Not bonded |
| TASF-11-1 | 10 | 10 | 150 | 0.1 | 62.5 |
| TASF-11-2 | 10 | 20 | 150 | 0.1 | 53.2 |
| TASF-12-1 | 10 | 20 | 200 | 0.2 | 58.6 |
| TASF-12-2 | 10 | 40 | 200 | 0.2 | 49.8 |
| TASF-13-1 | 10 | 40 | 50 | 0.5 | 45.1 |
| TASF-13-2 | 10 | 80 | 50 | 0.5 | 38.3 |
| TASF-14-1 | 10 | 10 | 100 | 0.7 | 57.7 |
| TASF-14-2 | 10 | 20 | 100 | 0.7 | 49.0 |
| TASF-15-1 | 10 | 20 | 150 | 1 | 63.2 |
| TASF-15-2 | 10 | 40 | 150 | 1 | 53.7 |
| TASF-16-1 | 10 | 30 | 200 | 1.5 | 43.6 |
| TASF-16-2 | 10 | 60 | 200 | 1.5 | 37.1 |
| TASF-17-1 | 10 | 10 | 100 | 2 | 42.3 |
| TASF-17-2 | 10 | 20 | 100 | 2 | 36.0 |
| TASF-18-1 | 10 | 20 | 200 | 2.5 | 39.5 |
| TASF-18-2 | 10 | 40 | 200 | 2.5 | 33.6 |
| Conventional material (Pb glass) | | | | | 65.5 |
| Conventional material (V-Te glass) | | | | | 67.3 |

What is claimed is:

1. A display apparatus comprising a rear substrate equipped with a plurality of electron sources and a front substrate equipped with a plurality of fluorescent materials wherein the substrates are oppositely placed to form a space therebetween and peripheral portions of the substrates are hermetically sealed with a bonding material to keep the sealed space under a reduced pressure; wherein

the bonding material is a mixture of a filler and a glass that contains vanadium and phosphorous as main ingredients and the glass is a vanadate-phosphate glass that contains V_2O_5 of 45 to 60%, P_2O_5 of 15 to 30%, BaO of 5 to 15%, and Sb_2O_3 of 5 to 10% (by weight) in converted values as oxides.

2. A display apparatus comprising a rear substrate equipped with a plurality of electron sources and a front substrate equipped with a plurality of fluorescent materials wherein the substrates are oppositely placed to form a space therebetween and the peripheral portions of the substrates are hermetically sealed with bonding material to keep the sealed space under a reduced pressure; wherein

the bonding material is made of a glass that contains at least vanadium, phosphorous, barium, and antimony; and amounts of the ingredients are 15 to 35% of BaO and Sb_2O_3 in total in converted values as oxides and a ratio of BaO to Sb_2O_3 or Sb_2O_3 to BaO is 0.3 or less.

3. The display apparatus according to claim 2, wherein the bonding material contains 20 to 90% (by volume) of a glass ingredient and 10 to 80% (by volume) of filler.

4. The display apparatus according to claim 3, wherein the filler is at least one selected from the group consisting of SiO_2 , ZrO_2 , Al_2O_3 , $ZrSiO_4$, cordierite, mullite, and eucryptite and a mean particle size thereof is 0.5 to 10 μm.

5. The display apparatus according to claim 2, wherein the glass contains 45 to 60% (by weight) of V_2O_5 in a converted value as vanadium oxide and 15 to 30% (by weight) of P_2O_5 in a converted value as phosphorous oxide.

6. The display apparatus according to claim 2, wherein a marginal frame is provided between the front and rear substrates.

7. The display apparatus according to claim 2, wherein the bonding material contains glass beads by 0.1 to 1.0% (by volume) of the bonding material whose particle size is 90 to 100% of a distance of the space between the front and rear substrates.

8. The display apparatus according to claim 2, wherein the front substrate has a peripheral rim that is curved and protruded towards the rear substrate, the front and rear substrates therewith being bonded to each other.

9. The display apparatus according to claim 2, wherein the glass contains at least one of Ag, Cu, Cs, Hf, Na, K and Te as an additive by 1 to 10% by weight in a converted value as oxides of Ag_2O , Cu_2O , Cs_2O , HfO_2 , Na_2O , K_2O and TeO_2 .

10. The display apparatus according to claim 1, wherein the glass is a vanadate-phosphate glass that contains V_2O_5 of 45 to 60%, P_2O_5 of 20 to 30%, BaO of 5 to 15%, TeO_2 of 0 to 10%, Sb_2O_3 of 5 to 10%, and WO_3 of 0 to 5% (by weight); the filler is at least one selected from the group consisting of silica glass, mullite, ceramic, fireclay refractory, steatite, alumina and spinel, and a particle size of the filler is 1 to 150 μm.

11. The display apparatus according to claim 10, wherein a coefficient of thermal expansion of the vanadate-phosphate glass is in a range of 60 to $90 \times 10^{-7}/^\circ C$. and a coefficient of thermal expansion of the filler is $60 \times 10^{-7}/^\circ C$. or less.

12. The display apparatus according to claim 11, wherein the bonding material is mixed with glass beads of 50 to 200 μm in size and the glass beads dispersed in the filler is 0.1 to 1.0% by volume.

13. The display apparatus according to claim 11, wherein the coefficient of thermal expansion of the glass beads is $60 \times 10^{-7}/^\circ C$. or less.

14. The display apparatus according to claim 11, wherein the display apparatus is a field emission type display that is equipped with two glass substrates one of which has the electron sources that emit electrons and the other of which is