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**United States Patent**

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#### (57) ABSTRACT

A glass bonding material contains vanadium and phosphor as main glass components, and comprises in amounts converted as oxides of the elements in the components, 45 to 60% by weight of  $V_2O_5$ , 15 to 30% by weight of  $P_2O_5$ , 5 to 25% by weight of BaO, or contains a glass comprising at least vanadium, phosphor, barium and antimony, wherein the glass comprises in amounts converted as oxides, 15 to 35% by weight of BaO and  $Sb_2O_3$  in total, and a weight ratio of BaO/ $Sb_2O_3$  or  $Sb_2O_3$ /BaO is 0.3 or less.

**11 Claims, 8 Drawing Sheets**

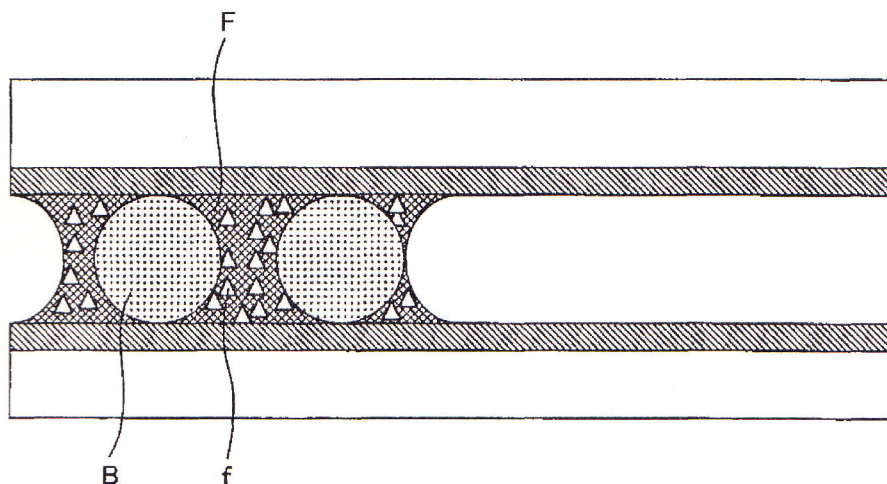




TABLE 5

No.	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-1-1	1	20	50	0.5	75.5
TASF-1-2	1	40	50	0.5	64.2
TASF-2-1	5	10	100	0.5	70.8
TASF-2-2	5	20	100	0.5	60.2
TASF-3-1	10	20	150	0.5	61.5
TASF-3-2	10	40	150	0.5	52.3
TASF-4-1	20	30	200	0.5	46.7
TASF-4-2	20	60	200	0.5	39.7
TASF-5-1	50	10	50	0.5	55.3
TASF-5-2	50	20	50	0.5	47.0
TASF-6-1	100	20	100	0.5	60.8
TASF-6-2	100	40	100	0.5	51.7
TASF-7-1	150	30	150	0.5	48.1
TASF-7-2	150	60	150	0.5	40.9
TASF-8-1	180	10	200	0.5	32.0
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 glass bonding material containing vanadium and phosphor as main glass components, which comprises in amounts converted as oxides of the elements in the components, 45 to 60% by weight of  $V_2O_5$ , 15 to 30% by weight of  $P_2O_5$ , and 5 to 15% by weight of BaO.

2. A glass bonding material containing a glass comprising at least vanadium, phosphor, barium and antimony, wherein the glass comprises in amounts converted as oxides, 5 to 15% by weight of BaO and 5 to 10% by weight of  $Sb_2O_3$ .

3. The glass bonding material according to claim 2, further comprising a filler.

4. The glass bonding material according to claim 2, wherein the filler is at least one member selected from the group consisting of silica group glass, mullite, ceramic materials, clay group refractory materials, steatite, alumina and spinel.

5. The glass bonding material containing according to claim 2, wherein the glass comprises in amounts converted as oxides 45 to 60% by weight of  $V_2O_5$ , and 15 to 30% by weight of  $P_2O_5$ .

6. The glass bonding material according to claim 2, further comprising glass beads in an amount of 0.1 to 1% by volume per the glass bonding material.

7. The glass bonding material according to claim 2, which contains Te as an additive in an amount converted as oxide 1 to 10% by weight.

8. The glass bonding material according to claim 1, which further contains a filler selected from the group consisting of silica group glass, mullite, ceramic materials, steatite, clay group refractory materials, alumina and spinel, and wherein the glass comprises 45 to 60% by weight, 20 to 30% by weight of  $P_2O_5$ , 5 to 15% by weight of BaO, 0 to 10 by weight of  $TeO_2$ , 5 to 10% by weight of  $Sb_2O_3$ , and 0 to 5% by weight of  $WO_3$ .

9. The glass bonding material according to claim 8, wherein the glass has a thermal linear expansion coefficient in a range of  $60$  to  $90 \times 10^{-7}/^\circ C.$ , and the filler has a linear thermal expansion coefficient of  $60 \times 10^{-7}/^\circ C.$  or less.

10. The glass bonding material according to claim 8, which further contains glass beads having a particle size of 50 to 200 μm and wherein an amount of the glass beads is 0.1 to 1% by volume.

11. The glass bonding material according to claim 10, wherein the glass beads have a linear thermal expansion coefficient of  $60 \times 10^{-7}/^\circ C.$  or less.

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