CLAIMS

1. An electronic device comprising:

a first glass substrate having a surface including a first sealing region;

a second glass substrate having a surface, the surface including a second sealing region corresponding to the first sealing region and disposed so as to face the surface of the first glass substrate;

an electronic element portion disposed between the first glass substrate and the second glass substrate; and

a sealing layer formed between the first sealing region of the first glass substrate and the second sealing region of the second glass substrate so as to seal the electronic element portion;

wherein the sealing layer comprises a melted and solidified layer which is obtained by locally heating a sealing material, the sealing material containing sealing glass, a low-expansion filler and an electromagnetic wave absorbent, and wherein reacted layers are produced in the first and second glass substrates by reaction with the sealing layer, each of the reacted layers having a maximum depth of at least 30 nm from an interface with the sealing layer.

2. The electronic device according to Claim 1, wherein the reacted layers have central portions formed in a shape protruding toward the first and second glass substrates in comparison with portions thereof in the vicinity of end portions.

3. The electronic device according to Claim 1 or 2, wherein each of the reacted layers has a cross-sectional area of at least 50 μm^2.

4. The electronic device according to any one of Claims 1 to 3, wherein the sealing glass comprises bismuth glass containing 70 to 90% of Bi_2O_3, 1 to 20% of ZnO, 2 to 12% of B_2O_3, and 10 to 380 ppm of Na_2O by mass proportion.

5. The electronic device according to any one of Claims 1 to 4, wherein the electromagnetic wave absorbent comprises a compound containing at least one metal selected from a group consisting of Fe, Cr, Mn, Co, Ni and Cu, or a compound containing such metal, and the sealing material contains the electromagnetic wave absorbent in a range of 0.1 to 40% by volume proportion.

6. The electronic device according to Claim 5, containing the electromagnetic wave absorbent in a range of 0.1 to 10% by volume property.

7. The electronic device according to any one of Claims 1 to 6, wherein the low-expansion filler comprises at least one member selected from the group consisting of silica, alumina, zirconia, zirconium silicate, aluminum titanate, mullite, cordierite, eucryptite, spodumene, a zirconium phosphate compound, a tin oxide compound and a silica solid solution, and the sealing material contains the low-expansion filler in a range of 1 to 50% by volume proportion.

8. The electronic device according to Claim 7, containing the low-expansion filler in a range of 10 to 50% by volume property.

9. The electronic device according to any one of Claims 1 to 8, wherein the sealing layer has a thickness of 2 to 15 μm and a width of 0.2 to 1.5 mm.

10. A process for producing an electronic device, comprising:

preparing a first glass substrate having a surface including a first sealing region;

preparing a second glass substrate having a surface including a second sealing region corresponding to the first sealing region, and a sealing material layer formed in the second sealing region, the sealing material layer comprising a fired layer of a sealing material containing sealing glass, a low-expansion filler and an electromagnetic wave absorbent, the sealing glass comprising bismuth glass containing 70 to 90% of Bi_2O_3, 1 to 20% of ZnO, 2 to 12% of B_2O_3, and 10 to 380 ppm of an alkaline metal oxide by mass proportion;

laminating the first glass substrate and the second glass substrate through the sealing material layer with the surface of the first glass substrate and the surface of the second glass substrate facing each other; and

irradiating the sealing material layer with an electromagnetic wave through the first glass substrate and/or the second glass substrate to locally heat the e sealing material layer such that when the sealing glass has a softening point temperature of T(°C), the sealing material layer is heated at a temperature in a range of at least (T+200°C) to at most (T+800°C), whereby the sealing material layer is melted to form a sealing layer to seal an electronic element portion disposed between the first glass substrate and the second glass substrate.

11. A process for producing an electronic device, comprising:

preparing a first glass substrate having a surface including a first sealing region;

preparing a second glass substrate having a surface including a second sealing

region corresponding to the first sealing region, and a sealing material layer formed on the second sealing region, the sealing material layer comprising a fired layer of a sealing material containing sealing glass, a low-expansion filler and an electromagnetic wave absorbent, the sealing glass comprising bismuth glass containing 70 to 90% of Bi_2O_3, 1 to 20% of ZnO, 2 to 12% of B_2O_3, and 10 to 380 ppm of Na_2O by mass proportion;

laminating the first glass substrate and the second glass substrate through the sealing material layer with the surface of the first glass substrate and the surface of the second glass substrate facing each other; and

irradiating the sealing material layer with an electromagnetic wave through the first glass substrate and/or the second glass substrate to locally heat the sealing material layer such that when the sealing glass has a softening point temperature of T(°C), the sealing material layer is heated at a temperature in a range of at least (T+200°C) to at most (T+800°C), whereby the sealing material layer is melted to form a sealing layer to seal an electronic element portion disposed between the first glass substrate and the second glass substrate.

12. The process according to Claim 10 or 11, wherein the step for forming the sealing layer comprises producing layers reacted with the sealing layer in the first and second glass substrates such that each of the reacted layers has a maximum depth of at least 30 nm from an interface with the sealing layer.

13. The process according to Claim 12, further comprising producing the reacted layers so as to have central portions formed in a shape protruding toward the first and second glass substrates in comparison with portions thereof in the vicinity of end portions.

14. The process according to any one of Claim 10 or 13, comprising irradiating the sealing material layer with laser light as the electromagnetic wave, the laser light having an output density in a range of 250 to 10,000 W/cm^2.

15. The process according to any one of Claim 10 or 14, comprising irradiating the sealing material layer with infrared light as the electromagnetic wave, the laser light having an output density in a range of 1 to 30 kW/cm^2.

16. The process according to any one of Claim 10 or 15, comprising wherein the bismuth glass in the sealing glass contains Na_2O in a range of 100 to 350 ppm, and

the sealing material layer is irradiated with the electromagnetic wave such that the sealing material layer is heated at a temperature in a range of at least (T+300°C) to at most (T+500°C).

What is claimed is:

1. An electronic device comprising:

a first glass substrate having a surface including a first sealing region;

a second glass substrate having a surface, the surface including a second sealing region corresponding to the first sealing region and disposed so as to face the surface of the first glass substrate;

an electronic element portion disposed between the first glass substrate and the second glass substrate; and

a sealing layer formed between the first sealing region of the first glass substrate and the second sealing region of the second glass substrate so as to seal the electronic element portion;

wherein the sealing layer comprises a melted and solidified layer which is obtained by locally heating a sealing material, the sealing material containing sealing glass, a low-expansion filler and an electromagnetic wave absorbent, and wherein reacted layers are produced in the first and second glass substrates by reaction with the sealing layer as a result of locally heating, each of the reacted layers having a maximum depth of at least 30 nm from an interface with the sealing layer,

wherein the reacted layers have central portions formed in a shape protruding toward the first and second glass substrates in comparison with portions thereof in the vicinity of end portions,

wherein said central portions and said end portions are relative to a width of said reacted layers.

2. The electronic device according to claim 1, wherein each of the reacted layers has a cross-sectional area of at least 50 μm2.

3. The electronic device according to claim 1, wherein the sealing glass comprises bismuth glass containing 70 to 90% of Bi2O3, 1 to 20% of ZnO, 2 to 12% of B2O3, and 10 to 380 ppm of Na2 O by mass proportion.

4. The electronic device according to claim 1, wherein the electromagnetic wave absorbent comprises a compound containing at least one metal selected from a group consisting of Fe, Cr, Mn, Co, Ni and Cu, or a compound containing such metal, and the sealing material contains the electromagnetic wave absorbent in a range of 0.1 to 40% by volume proportion.

5. The electronic device according to claim 4, containing the electromagnetic wave absorbent in a range of 0.1 to 10% by volume proportion.

6. The electronic device according to claim 1, wherein the low-expansion filler comprises at least one member selected from the group consisting of silica, alumina, zirconia, zirconium silicate, aluminum titanate, mullite, cordierite, eucryptite, spodumene, a zirconium phosphate compound, a tin

oxide compound and a silica solid solution, and the sealing material contains the low-expansion filler in a range of 1 to 50% by volume proportion.

7. The electronic device according to claim 1, containing the low-expansion filler in a range of 10 to 50% by volume proportion.

8. The electronic device according to claim 1, wherein the sealing layer has a thickness of 2 to 15 μm and a width of 0.2 to 1.5 mm.

9. A process for producing the electronic device of claim 1, comprising:

preparing a first glass substrate having a surface including a first sealing region;

preparing a second glass substrate having a surface including a second sealing region corresponding to the first sealing region, and a sealing material layer formed in the second sealing region, the sealing material layer comprising a fired layer of a sealing material containing sealing glass, a low-expansion filler and an electromagnetic wave absorbent, the sealing glass comprising bismuth glass containing 70 to 90% of Bi2O3, 1 to 20% of ZnO, 2 to 12% of B2O3, and 10 to 380 ppm of an alkaline metal oxide by mass proportion;

laminating the first glass substrate and the second glass substrate through the sealing material layer with the surface of the first glass substrate and the surface of the second glass substrate facing each other; and

irradiating the sealing material layer with an electromagnetic wave through the first glass substrate and/or the second glass substrate to locally heat the e sealing material layer such that when the sealing glass has a softening point temperature of T(° C.), the sealing material layer is heated at a temperature in a range of at least (T+200° C.) to at most (T+800° C.), whereby the sealing material layer is melted to form a sealing layer to seal an electronic element portion disposed between the first glass substrate and the second glass substrate.

10. The process according to claim 9, wherein the step for forming the sealing layer comprises producing layers reacted with the sealing layer in the first and second glass substrates such that each of the reacted layers has a maximum depth of at least 30 nm from an interface with the sealing layer.

11. The process according to claim 10, further comprising producing the reacted layers so as to have central portions formed in a shape protruding toward the first and second glass substrates in comparison with portions thereof in the vicinity of end portions.

12. The process according to claim 9, comprising irradiating the sealing material layer with laser light as the electromagnetic wave, the laser light having an output density in a range of 250 to 10,000 W/cm2.

13. The process according to claim 9, comprising irradiating the sealing material layer with infrared light as the electromagnetic wave, the laser light having an output density in a range of 1 to 30 kW/cm2.

14. The process according to claim 9, comprising wherein the bismuth glass in the sealing glass contains Na2O in a range of 100 to 350 ppm, and the sealing material layer is irradiated with the electromagnetic wave such that the sealing material layer is heated at a temperature in a range of at least (T+300° C.) to at most (T+500° C.).

15. A process for producing the electronic device of claim 1, comprising:

preparing a first glass substrate having a surface including a first sealing region;

preparing a second glass substrate having a surface including a second sealing region corresponding to the first sealing region, and a sealing material layer formed in the second sealing region, the sealing material layer comprising a fired layer of a sealing material containing sealing glass, a low-expansion filler and an electromagnetic wave absorbent, the sealing glass comprising bismuth glass containing 70 to 90% of Bi2O3, 1 to 20% of ZnO, 2 to 12% of B2O3, and 10 to 380 ppm of Na2O by mass proportion;

laminating the first glass substrate and the second glass substrate through the sealing material layer with the surface of the first glass substrate and the surface of the second glass substrate facing each other; and

irradiating the sealing material layer with an electromagnetic wave through the first glass substrate and/or the second glass substrate to locally heat the sealing material layer such that when the sealing glass has a softening point temperature of T(° C.), the sealing material layer is heated at a temperature in a range of at least (T+200° C.) to at most (T+800° C.), whereby the sealing material layer is melted to form a sealing layer to seal an electronic element portion disposed between the first glass substrate and the second glass substrate.

16. The process according to claim 15, wherein the step for forming the sealing layer comprises producing layers reacted with the sealing layer in the first and second glass substrates such that each of the reacted layers has a maximum depth of at least 30 nm from an interface with the sealing layer.

17. The process according to claim 15, further comprising producing the reacted layers so as to have central portions formed in a shape protruding toward the first and second glass substrates in comparison with portions thereof in the vicinity of end portions.

18. The process according to claim 15, comprising irradiating the sealing material layer with laser light as the electromagnetic wave, the laser light having an output density in a range of 250 to 10,000 W/cm2.

19. The process according to claim 15, comprising irradiating the sealing material layer with infrared light as the electromagnetic wave, the laser light having an output density in a range of 1 to 30 kW/cm2.

20. The process according to claim 15, comprising wherein the bismuth glass in the sealing glass contains Na2O in a range of 100 to 350 ppm, and the sealing material layer is irradiated with the

electromagnetic wave such that the sealing material layer is heated at a temperature in a range of at least (T+300° C.) to at most (T+500° C.).

21. The electronic device according to claim 1, wherein a maximum depth D1 is at least 1.1 times a depth D2 in a vicinity of an end portion of said sealing layer.