

envisionable; nevertheless, the cost of these specific materials combined with that of circuit-transfer technologies is still too high for mass adoption of these solutions.

OBJECT OF THE INVENTION

Embodiments of the invention seek to provide a substrate suitable for radiofrequency applications, which may remedy all or some of the drawbacks of the prior art.

BRIEF DESCRIPTION OF THE INVENTION

An aspect of the invention provides a substrate for radiofrequency microelectronic devices comprising a carrier substrate, an intermediate layer, a useful layer arranged on the intermediate layer, characterized in that the carrier substrate is made of a semiconductor material and in that the substrate comprises a sintered composite layer which is arranged on the carrier substrate and is formed from a powder mixture of at least a first dielectric material and a second dielectric material different from the first, the nature of the first material, the nature of the second material, and the proportion of said materials in the powder mixture being selected to provide the sintered composite layer with a thermal expansion coefficient matching that of the carrier substrate within plus or minus 30%, said sintered composite layer having a thickness of between 5 microns and 100 microns, the intermediate layer being arranged on the sintered composite layer.

According to advantageous features of the invention, taken alone or in combination:

- the thermal expansion coefficient of the sintered composite layer is matched with that of the carrier substrate, to plus or minus 10%, or even to plus or minus 5%;
- the carrier substrate has a resistivity higher than 500 ohm.cm;
- the carrier substrate is made of silicon;

- the first and second dielectrics are chosen from silicon oxide, silicon nitride, aluminium nitride, alumina, and mullite;
- the substrate comprises a protective layer placed between the carrier substrate and the sintered composite layer;
- the substrate comprises an intermediate layer placed on the sintered composite layer;
- the intermediate layer is a dielectric layer formed from a material chosen from a silicon oxide, a silicon nitride, a silicon oxynitride, and an aluminium nitride;
- the substrate comprises a useful layer placed on the intermediate layer;
- the useful layer is composed of a material chosen from the semiconductors, insulators or conductors, or even the piezoelectrics.

Another aspect of the invention provides a radiofrequency-microelectronic-device structure comprising:

- a substrate such as above;
- a layer of microelectronic devices arranged on said substrate.

According to example embodiments, the microelectronic device is an antenna adapter or switch or a power amplifier or a low-noise amplifier or a passive component or other circuit operating at high frequency or a radiofrequency MEMS component or even a radiofrequency filter.

Another aspect of the invention provides a method for producing a substrate for radiofrequency microelectronic devices, comprising the following steps:

- a) Providing a carrier substrate made of a semiconductor material having a first surface;
- b) Depositing a layer, which is formed of a powder mixture of at least a first dielectric material and a second dielectric material different from the first, on the first surface of the carrier substrate;
- c) Sintering the layer formed from the powder mixture in order to obtain a sintered composite layer secured to the first surface of the carrier substrate and having a thickness of between 5 microns and 100 microns; the first material, the second material and the proportion of said materials in the powder mixture being selected to provide the sintered composite layer a thermal expansion coefficient matching that of the carrier substrate within more or less 30%;
- d) Assembling a useful layer and the carrier substrate so as to arrange the sintered composite layer between the useful layer and the carrier substrate, an intermediate layer being arranged between the useful layer and the sintered composite layer.

According to advantageous features of the invention, taken alone or in combination:

- the first side of the carrier substrate comprises a protective layer, prior to the deposition of the layer formed from the mixture of powders in step b);
- the protective layer is formed by at least one material chosen from silicon nitride, silicon oxynitride, and silicon oxide;
- the mixture of powders takes the form of a viscous paste, and the layer formed by said mixture is deposited, in step b), by spin coating;

- the deposition of the layer formed by the mixture of powders is followed by a low-temperature heat treatment in order to remove at least one liquid component from the viscous paste;
- the process comprises, after step c), a step d) of bonding a useful layer and the carrier substrate so as to place the sintered composite layer between the useful layer and the carrier substrate;

CLAIMS

1. Substrate for radio-frequency microelectronic devices,
comprising:

- a carrier substrate,

- an intermediate layer,

- a useful layer arranged on the intermediate layer,

characterized in that the carrier substrate is made of semiconductor material and in that the substrate comprises a sintered composite layer which is arranged on the carrier substrate and is formed from a powder mixture of at least a first dielectric material and a second dielectric material different from the first, the nature of the first material, the nature of the second material, and the proportion of said materials in the powder mixture being selected to provide the sintered composite layer with a thermal expansion coefficient matching that of the carrier substrate within plus or minus 30%, said sintered composite layer having a thickness of between 5 microns and 100 microns, the intermediate layer being arranged on the sintered composite layer.

2. Substrate for radio-frequency microelectronic devices according to the preceding claim, wherein the sintered composite layer has a thickness of between 10 microns and 100 microns.

3. Substrate for radio-frequency microelectronic devices according to either of the preceding claims, wherein the resistivity of the carrier substrate is higher than 500 ohm.cm.

4. Substrate for radio-frequency microelectronic devices according to any of the preceding claims, wherein the first carrier substrate is silicon.

5. Substrate for radio-frequency microelectronic devices according to any of the preceding claims, wherein the first and second dielectric materials are selected from silicon oxide, silicon nitride, aluminum nitride, alumina, mullite.

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6. Substrate for radio-frequency microelectronic devices according to any of the preceding claims, comprising a protective layer arranged between the carrier substrate and the sintered composite layer.

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7. Substrate for radio-frequency microelectronic devices according to any of the preceding claims, wherein the intermediate layer is a dielectric layer formed of a material selected from a silicon oxide, a silicon nitride, a silicon oxynitride, an aluminum nitride.

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8. Substrate for radio-frequency microelectronic devices according to any of the preceding claims, wherein the useful layer is composed of a material selected from semiconductor, insulating or conductive materials, or even piezoelectric materials.

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9. Structure of radio-frequency microelectronic devices comprising:

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- a substrate according to the preceding claim;

- a layer of microelectronic devices arranged on said substrate.

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10. Structure of radio-frequency microelectronic devices according to the preceding claim, wherein the microelectronic device is an antenna switch or adapter or a power amplifier or a low noise amplifier or a passive component or other circuit operating at high frequency or an MEMS radio-frequency component or a radio-frequency filter.

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11. Method for producing a substrate for radio-frequency microelectronic devices, characterized in that it comprises the following steps:

5 a) providing a carrier substrate made of a semiconductor material having a first surface;

 b) depositing a layer, which is formed of a powder mixture of at least a first dielectric material and a second dielectric material different from the first, on the first surface of the carrier substrate;

10 c) sintering the layer formed of the powder mixture to obtain a sintered composite layer secured to the first surface of the carrier substrate and having a thickness of between 5 microns and 100 microns; the first material, the second material and the proportion of said materials in the powder mixture being selected to provide the sintered composite layer with a thermal expansion coefficient matching that of the carrier substrate within more or less 30%;

20 d) assembling a useful layer and the carrier substrate so as to arrange the sintered composite layer between the useful layer and the carrier substrate, an intermediate layer being arranged between the useful layer and the sintered composite layer.

12. Method for producing a substrate for radio-frequency microelectronic devices according to the preceding claim, wherein the first surface of the carrier substrate comprises a protective layer, prior to the deposition of the layer formed of the powder mixture from step b).

35 13. Method for producing a substrate for radio-frequency microelectronic devices according to the preceding claim, wherein the protective layer is formed by at least one material

selected from silicon nitride, silicon oxynitride, silicon oxide.

5 14. Method for producing a substrate for radio-frequency microelectronic devices according to any of the three preceding claims, wherein the powder mixture is in the form of a viscous paste, and the deposition of the layer formed by said mixture in step b) is carried out by spin coating.

10 15. Method for producing a substrate for radio-frequency microelectronic devices according to the preceding claim, wherein the deposition of the layer formed by the powder mixture is followed by a low-temperature heat treatment to remove at least one liquid component from the viscous paste.

15 16. Method for producing a substrate for radio-frequency microelectronic devices according to one of the two preceding claims, wherein the useful layer provided for the assembly step d) is a donor substrate composed of a material selected from
20 semiconductor, insulating or conductive materials, or even piezoelectric materials.

25 17. Method for producing a substrate for radio-frequency microelectronic devices according to the preceding claim, comprising a step e) of thinning the donor substrate to the desired thickness of the useful layer for the production of radio-frequency microelectronic devices.