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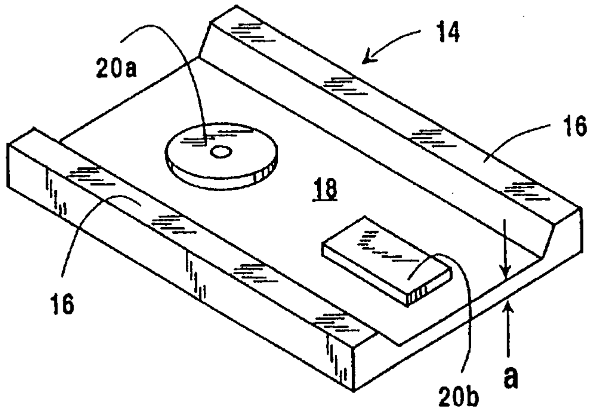

(57) Abstract

A method of heat treating ceramic-based electronic components (20a, 20b) by providing a furnace fixture (14) adapted to support the ceramic-based electronic components (20a, 20b) which is made from a substrate selected from the group consisting of silicon carbide, cordierite, mullite, stabilized zirconia, magnesium oxide and alumina containing a glassy bond phase. A cladding layer of zirconia or magnesia is then deposited on the furnace fixture substrate by plasma deposition. The ceramic-based electronic based components (20a, 20b) to be fired are placed on the zirconia-coated substrate (18); and heated to a desired temperature to heat treat the components (20a, 20b).

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Description

METHOD AND APPARATUS FOR PRODUCING CERAMIC-BASED ELECTRONIC COMPONENTS

This application is a continuation-in-part of U.S. serial no. 075,683 filed June 11, 1993.

Technical Field

This invention relates to a method and apparatus for producing ceramic-based electronic and other components, and more particularly to a particular combination of ceramic compositions useful for fixtures for heat treating such components.

Background Art

Components in electronic circuitry utilize ceramic materials for both substrates and semiconductor packages. However, the most common type of ceramic-based electronic components for which the present invention is useful in heat treating are ceramic capacitors, resistors, thermistors or the like which are typically made up of multiple layers of oxide or nonoxide ceramics having suitable dielectric properties. Common sizes are 0.08 x 0.05 in., 0.125 x 0.063 in. and 0.5 x 0.225 in. Multilayer ceramics are also used as substrates for integrated circuit packages. Alumina-based ceramics are widely employed, as well as mullite ($3Al_2O_3 \cdot 2SiO_2$), beryllia (BeO), aluminum nitride (AlN) and various other well known glass-ceramic materials, depending on the dielectric constant, coefficient of thermal expansion, and other properties desired. Different classifications for ceramic dielectric materials are Class I dielectrics with low *k* (dielectric constant) values made by mixing magnesium titanate with calcium titanate; Class II dielectrics with high *k* values (also known as ferroelectrics) based on barium titanate, optionally with additions of barium stanate, barium zirconate or magnesium titanate; and Class III dielectrics. Other ceramic materials used in electronic applications include magnesia; nickel manganates ($NiO \cdot MnO_2$); zirconia (ZrO_2); yttria (Y_2O_3); lead compounds such as lead oxide (PbO), lead non-oxides, lead zirconium titanates, lead titanates, and lead metaniobates; beryllium compounds such as BeO; ferrous oxide compounds (e.g., magnetic and non-magnetic FeO compounds, including those in mixture or compound with Zn and/or Mn) and ferrites. Ferrites are a well known class of ceramics having the spinel cubic structure of the general formula XFe_2O_4, where X may represent Ba, Zn, CD, Cu, Mg, Co, Ni, Mn, Fe or a mixture of these or other ions.

In processing such ceramic-based electronic components, the parts in the "green" state are fired one or more times to temperatures of approximately 1000°C - 1700°C and higher, more typically 1100°C - 1500°C, to achieve vitrification, sintering and/or densification. Total cycle times for heat treatment are typically eight (8) hours or longer, although shorter times may be used where there is only a small mass of product. Firing may be done under a vacuum or protective atmosphere but is typically done in air. Standard type furnaces or kilns employed in the industry are typically either the pusher or tunnel type and the periodic or batch type.

The devices or fixtures by which the ceramic components are physically supported during the firing process are generally termed furnace or kiln furniture. Other well known nomenclature is utilized for various configurations and types of fixtures such as saggers, setters, and plates, and varieties of substrates with rails or sidewalls. Processes used for manufacturing prior art monolithic furnace fixtures include press cast molding, powder roll compaction, tape casting, slip casting or extrusion of the green ceramics to the desired shape, followed by firing of these materials in the range of temperatures given previously. A wide variety of ceramic materials have been employed such as the aforementioned and other alumina and alumina-based ceramics, as well as zirconia and magnesia. In some instances, powdered forms of these ceramics have been applied to furnace fixtures either as dry powders or aqueous washes which are then dried to leave a powder residue, to prevent sticking of the components to the fixture surface.

Although the prior art methods of using these monolithic furnace fixtures have not changed dramatically over the years, there has been a long sought need to reduce furnace time and associated energy costs to maximize productivity in processing ceramic-based electronic components. With some types of fixture materials, especially those which have low reactivity with typical ceramics used in electronics, this has been difficult because of the relatively thick fixture cross sections necessitated for purposes of maintaining strength and thermal shock resistance. In some instances, the fixture panels had high porosity and a rough surface, and were not considered mechanically suitable for use in thin, large panels which are desirable for maximizing the number of components which may be placed in the furnace. The result has been that a relatively large amount of furnace heat goes to heating the fixtures themselves, which not only costs more fuel but also penalizes the process by requiring longer heat up and cool down time for the combined mass of fixtures and electronic components. Ceramic materials which have greater strength, can be easily processed to flatness and other dimensional parameters, and can withstand cyclic exposure to high temperature firing such as alumina do not have the degree of chemical inertness needed for processing many of the variety of ceramics used in electronics, and therefore have only limited potential for use.

Similar problems have been encountered in firing other ceramic components from the green state. Other components include those made from zirconium oxide (ZrO2), such as oxygen sensors used to regulate internal combustion engines.

Bearing in mind the problems and deficiencies of the prior art, it is therefore an object of the present invention to provide a process for heat treating ceramic-based electronic and other components which reduces the time and energy required to fire the components, while at the same time providing a surface for contacting the component which is relatively inert so as to avoid chemical contamination of the ceramics employed in the components.

It is another object of the present invention to provide furnace fixtures for processing ceramic-based electronic and other components which have a relatively thin cross section while having a high degree of strength and resistance to thermal cycles at the temperatures and conditions employed in heat treating such components.

It is a further object of the present invention to provide furnace fixtures for processing ceramic-based electronic and other components which may be produced to close tolerances for flatness and other dimensional parameters.

It is yet another object of the present invention to provide a process for heat treating ceramic-based electronic and other components in which the furnace fixtures eliminate sticking of the components to the fixture surface and have a long working life.

It is a further object of the present invention to provide furnace fixtures for processing ceramic-based electronic and other components in which the total volume of fixture material is reduced and the volume of furnace space which is available for components to be heat treated is increased.

Disclosure Of The Invention

The above and other objects, which will be apparent to those skilled in the art, are achieved in the present invention which in one aspect relates to a method of heat treating ceramic-based electronic and other components by providing a furnace fixture adapted to support the ceramic-based electronic components which is made from a substrate selected from the group consisting of silicon carbide (SiC), cordierite ($2MgO \cdot 2Al2O_3 \cdot 5SiO_2$), mullite ($3Al_2O_3 \cdot 2SiO_2$), stabilized zirconia, magnesium oxide (MgO) and alumina (Al_2O_3) containing a glassy bond phase. A cladding layer of zirconia or magnesia is then deposited on the furnace fixture substrate by plasma deposition. The ceramic-based component to be fired is placed on the zirconia- or magnesia-coated substrate and heated to a desired temperature to heat treat the component.

In another aspect, the invention relates to an apparatus or system for heat treating ceramic-based electronic components comprising a furnace and a furnace fixture having a substrate selected from the group consisting of silicon carbide (SiC), cordierite ($2MgO \cdot 2Al2O_3 \cdot 5SiO_2$), mullite ($3Al_2O_3 \cdot 2SiO_2$), stabilized zirconia, magnesium oxide (MgO) and alumina containing a glassy bond phase. The substrate is clad by a bonded layer of plasma-deposited zirconia or magnesia, and the zirconia- or magnesia-clad fixture substrate supports the ceramic-based component for firing.

In a further aspect, the invention relates to a fixture for heat treating ceramic based components comprising a base having an upper surface for supporting the ceramic based component, wherein the base has a substrate selected from the group consisting of silicon carbide (SiC), cordierite ($2MgO \cdot 2Al2O_3 \cdot 5SiO_2$), mullite ($3Al_2O_3 \cdot 2SiO_2$), stabilized zirconia, magnesium oxide (MgO) and alumina containing a glassy bond phase. The base substrate is clad on at least a portion of its upper surface by an impermeable top layer of plasma-deposited zirconia or magnesia. A pair of integral side rails on opposite ends of said base extend above the upper surface and are spaced and have a height above the top surface of the base greater than the width and height, respectively, of the ceramic-based electronic component to be heat treated on the zirconia- or magnesia-clad portion of the fixture.

The preferred substrate comprises a thin plate of less than 0.100 in. made from alpha alumina in an amount no greater than about 98% by weight of the substrate and at least about 2% by weight of an oxide of silicon or an alkali or alkaline earth metal, or combinations thereof. The cladding preferably comprises a smooth, impervious layer of stabilized cubic zirconia or magnesium oxide in a thickness of 0.0001-0.010 in.

Brief Description of the Drawings

Fig. 1 is a side elevational view of the furnace apparatus of the present invention employing zirconia- or magnesia-clad furnace fixtures supporting ceramic-based electronic components for heat treatment.

Fig. 2 is a perspective view of a zirconia- or magnesia-clad furnace fixture of Fig. 1 supporting ceramic-based electronic components.

Fig. 3a is a cross-sectional view through a first embodiment of the furnace fixture of Fig. 2 showing the zirconia or magnesia coating layer on all sides of the fixture.

Fig. 3b is a cross-sectional view through a second embodiment of the furnace fixture of Fig. 2 showing the zirconia or magnesia coating layer on only the upper component-supporting surface of the fixture.

Fig. 4 is a perspective view of another zirconia- or magnesia-clad furnace fixture for supporting ceramic-based electronic components which employs separate spacer rails.

Modes For Carrying Out The Invention

The most common type of ceramic-based component for which the present invention is useful in heat treating are electronic components such as ceramic capacitors which are typically made up of multiple layers of ceramics having suitable dielectric properties, although the invention may be utilized for processing any of the aforementioned types of electronic and other components and ceramic materials previously discussed in the background section of this application. The present invention is based on the discovery that improved furnace fixtures for heat treating ceramic-based electronic components, also known as "kiln furniture", may be produced by depositing a solid cladding layer of zirconia or magnesia by plasma deposition in air over certain ceramic substrates. Such furniture fixtures are found to possess higher strength and better protection of the ceramic components (preventing sticking and contamination thereof) in smaller cross sections, which results in faster furnace and component heat-up rates and closer packing of components in the furnace, and which ultimately reduces the unit energy required to heat treat the ceramic-based electronic components.

For purposes of the present invention, the furniture fixture materials which have been found to be most desirable as substrates for the zirconia or magnesia coating are: 1) silicon carbide (SiC); 2) cordierite ($2MgO \cdot 2Al_2O_3 \cdot 5SiO_2$); 3) mullite ($3Al_2O_3 \cdot 2SiO_2$); 4) zirconia stabilized with calcia, magnesia or yttria; 5) magnesium oxide (MgO) and, preferably, 6) alumina (Al_2O_3) having alpha alumina crystals bound by a bond phase of silica (SiO_2) and/or other glassy oxides such as magnesia (MgO), calcia (CaO), sodium monoxide (Na_2O), ferric oxide (Fe_2O_3), zirconia (ZrO_2), or combinations of the above. The preferred alumina containing the glassy bond phase contains silica and has a composition of no greater than about 98% Al_2O_3, and at least about 2% silica and/or the other aforementioned oxides, and more preferably has a composition of 96% Al_2O_3 and 2.5-3.0% SiO_2. (Unless otherwise noted, all references herein to composition percentages are in weight percent of the total.) Higher amounts of silica, up to about 25%, in the preferred alumina substrate composition have been shown to provide good bonding with the plasma deposited zirconia or magnesia, with no other adverse effects on manufacturing, operation and use of the invention. Additionally, zirconia (ZrO_2) may be added as a component to the preferred alumina containing the glassy bond phase to provide zirconia toughened alumina , also known as "ZTA", which may be employed as a substrate material for the furnace fixtures of the present invention. The addition of unstabilized zirconia provides toughness for resistance to shock in extended thermal cycles.

Processes used for manufacturing the furnace fixtures include molding, powder roll compaction, tape casting, slip casting or extrusion of the green ceramics to the desired plate-like shape, followed by firing of these materials, as described previously. These aforementioned preferred fixture substrate materials generally provide strong, thermally shock resistant platforms for the electronic components at base section thickness of less than 0.100 in., preferably 0.040-0.060 in., and at lengths and widths of 3-6 in. When stacked and separated by spacers, these relatively thin fixture plates maximize the volume available inside the furnace for the ceramic-based electronics products themselves, which can have thicknesses up to 0.025 in. and higher. Naturally, if desired for special applications, the fixture panels may be manufactured and used in the higher thickness employed in the prior art, typically up to 0.500 in. However, unlike the previously utilized monolithic panels of zirconia which typically required a thickness over 0.100 and up to 0.400 in. or more, and had high porosity and a rough surface, the substrate panels to be utilized in the present invention have relatively dense, smooth surfaces and are mechanically suitable for use in thin, large panels.

The zirconia to be plasma sprayed as the coating or cladding over the aforementioned fixture substrate materials is preferably stabilized to a cubic matrix by the addition of oxide stabilizers such as magnesia (MgO), calcia (CaO), yttria (Y_2O_3), lanthana (La_2O_3) and Ce_2O_3. The zirconia to be plasma deposited is more preferably stabilized with magnesia and has a composition of approximately 76% ZrO_2 (unstabilized) and 24% MgO, although calcia- and/or yttria-stabilized zirconia are also believed especially useful. In the case where the zirconia is plasma sprayed over a zirconia substrate (manufactured as described previously), the zirconia coating contrasts with the substrate by its substantially increased density and smoother surface, as-deposited. The preferred particle size of the zirconia is 140 - 325 U.S. Mesh , although other particle sizes may be utilized with different application equipment. As indicated, the stabilized zirconia is deposited on the ceramic furnace fixture substrate by plasma deposition, which is a well known process utilized in other industries. The plasma deposition may take place in air or in a protective or inert atmosphere. Prior to applying the plasma spray deposition, it is desirable to prepare the surface of the substrate by grit blasting to clean and roughen the surface to promote adhesion and bounding of the solid zirconia layer. Plasma deposition takes place by ionizing the carrier gas, adding zirconia powder and applying it by conventional plasma gun to a desired thickness inches at a predetermined traverse and feed rates. While any suitable thickness of zirconia may be utilized, such as up to 0.025 in or more, typically the zirconia topcoat layer may range from about 0.0001 to about 0.0100 in., preferably from about 0.0005 to about 0.035-0.0040 in., most preferably 0.0015 in. As-deposited the preferably stabilized zirconia provides a thin yet solid, smooth, essentially pore free, impermeable coating over desired areas of the fixture substrate material coming in contact with the ceramic components. The relatively inert zirconia cladding is especially useful in preventing contamination of the electronic components from the silica and the alumina in the silicon carbide, cordierite, mullite and preferred alumina substrates. For additional smoothness, the surface may be sanded with a light abrasive after plasma deposition.

Magnesia may be applied by plasma deposition in the same manner as described herein for zirconia. As used herein, "magnesia" as a cladding includes not only the compound magnesium oxide (MgO), but also includes spinel, the solid state reaction between magnesium oxide (MgO) and alumina (Al_2O_3), also known as $MgO{\cdot}Al_2O_3$ or $MgAl_2O_4$. Spinel can be adjusted for a wide range of MgO Al_2O_3 ratios, although a weight ratio of 1:3 is preferred. Magnesium oxide (MgO) in powder form preferable contains up to about 8% yttria (Y_2O_3) and may contain minor or trace amounts of SiO_2, Al_2O_3, Fe_2O_3, Na_2O or other compounds as present in commercially available product. Similar cladding layer thicknesses may be deposited, most preferably in the range of about 0.003-0.010 in., to yield the thin, solid, smooth and impermeable coating. Where magnesia is applied over a magnesium oxide (MgO) substrate, for example, the plasma-deposited coating has greater density and impermeability, and fewer impurities, than may be manufactured in the substrate.

The method and apparatus provided by the present invention stands in contrast with the prior art in which unstabilized or essentially pure zirconia or alumina flour was applied in either dry form or a wash over the surface of the monolithic ceramic materials described previously for furnace fixtures. In such prior art, the zirconia and alumina powders added nothing to the strength or properties of the furnace fixtures, and required reapplication after every use.

In operation, the ceramic-based electronic or other components are typically spaced single height on the zirconia or magnesia-clad surface of the fixtures produced by the process of the present invention. These fixtures are then stacked one upon the other utilizing spacers, which may be integral rails on the fixtures or separate pieces. Preferably, the spacers themselves are zirconia or magnesia clad to reduce sticking between adjacent pieces. The stacked components are then placed inside the furnace and heated to the firing temperature for a desired time. The heat treating temperatures of approximately 1000°C - 1700°C used to fire the ceramic components, while sometimes being within the vitrification range of the particular ceramic, is below that at which the components become substantially molten. The particular combination of a relatively thin plasma deposited zirconia or magnesia layer on a substrate of alumina having a glassy bond phase results in a heating rate that is considerably faster than if the same thickness of zirconia or magnesia is utilized as the furniture fixture. At the thicknesses described herein, the zirconia coated substrate of alumina having the glassy bond phase will have a heating rate that is approximately 14 times higher than that of a monolithic zirconia plate of similar thickness. Where a zirconia-clad alumina plate of 0.060 in. thickness replaces a prior art plate of zirconia of 0.240 in. thickness, the heating rate will be more than 200 times faster.

While prior art fixtures such as monolithic zirconia in the relatively thick sections employed had good thermal shock resistance, believed to be due in part to the porosity present which arrests crack propagation, the alumina containing the glassy bond phase preferred as the fixture substrate of the present invention is believed to have comparable or better properties in this regard, despite having typically thinner (0.060 in.) sections and higher density. Furthermore, the bonding of the plasma-deposited zirconia or magnesia to the substrates to be employed in the present invention is extremely strong so that a long working life of the zirconia or magnesia-clad fixtures is expected. While not wishing to be bound by theory, it is believed that the presence of the thin glassy layers at the boundary of the alpha alumina crystals of the preferred composition of the present invention results in high thermal shock resistance, and that the thermally induced interface stresses between the zirconia or magnesia coating and alumina substrate are negligible as a practical matter. Additionally, it is believed that these characteristics of the alumina containing a glassy bond phase results in a stronger bond between the zirconia or magnesia layer and the alumina substrate. Bond strength of the zirconia is expected to be enhanced over time because of solid state diffusion expected along the zirconia/substrate interface. The possible presence of a spinel, generically designated as a structural group: XY_2O_4, and more commonly known as the mineral $MgO \cdot Al_2O_3$ (or $MgAl_2O_4$), is believed to contribute to the favorable characteristics of the invention described herein.

With reference to the drawings, which are not necessarily shown to scale, Fig. 1 is a side elevational view of the furnace apparatus of the present invention employing zirconia-clad furnace fixtures supporting ceramic-based electronic components for heat treatment. Furnace 10 has a thermally insulative lining 11 and a base plate 12 of any desired refractory material for supporting the mass of fixtures and components. A plurality of zirconia- or magnesia-clad fixtures or setters 14 having integral side rails 16 are stacked upon each other within furnace 10. Disposed upon the fixture upper supporting surfaces 18 are a plurality of ceramic-based electronic components 20, which due to the greater height of rails 16, have sufficient space above and to the sides to prevent contact between one another and the lower surface of the fixture above. At least the flat upper supporting surface 18 of each fixture 14 is zirconia or magnesia-clad to prevent chemical contamination of the components 20 by the fixture substrate material of the type described previously. As shown more clearly in Fig. 2, for maximum heating efficiency, the supporting surface thickness "a" of the fixture 14 is kept to a minimum, preferably below 0.100 in., more preferably 0.040-0.060 in., so as to maximize the mass of components 20a and 20b contained in a given internal volume of the furnace. The typical width and depth dimensions of the fixtures, on the order of 4-6 in., makes flatness of the fixture important at such thin sections.

Cross-sectional views of fixture 14 are shown in Figs 3a and 3b. In Fig. 3a, the zirconia or magnesia 22a is shown deposited on the supporting surface 18a and all other sides of the fixture, whereas in Fig. 3b the zirconia or magnesia 22b is shown deposited on only the supporting surface 18b, leaving the fixture substrate material exposed on the remaining sides. For maximum performance and life, all sides of the fixture substrate should be zirconia- or magnesia-clad.

An alternate configuration of a furnace fixture is depicted in Fig. 4 in which a flat, rectangular, zirconia- or magnesia-clad fixture plate 24 supports components 20a and 20b on its supporting surface 18. Plate 24 employs separate rails or spacers 26 of 0.250 in. thickness to separate and support adjacent levels of fixtures. The ceramic-based electronic components generally have a thickness of under 0.250 in., but thicker spacers or rails are used for larger components. Fixtures of the type shown in Figs. 2 and 4 may be stacked up to 30-50 levels high in a typical furnace having interior dimensions of 18 in. x 18 in. x 18 in.

Example

As a non-limiting example of the present invention, a furnace fixture substrate, or "setter", comprised of a silica-containing alumina has a typical analysis as follows (in weight percent):

Al_2O_3	96
SiO_2	2.5-3.0
MgO	0.75-1.0
CaO	0.10-0.25
Na_2O	0.05-0.10 max.
Fe_2O_3	0.03-0.05
ZrO_2	0-0.05

This alumina has a glassy bond phase between alpha alumina crystals and is fabricated by casting or extrusion to a size of 4.5 x 4.5 in. and thickness of 0.060 in. The surface of the setter is then grit blasted with no. 220 aluminum oxide grit at an air pressure of 65 to 70 psi at a gun distance of 4 to 5 inches and angle of 90° to obtain an even matte finish, with concentration on edge areas to provide good bonding properties for the zirconia coating. Avoiding contact with the skin, the setter is then ready for plasma deposition of the zirconia powder, which, without further protection, should be performed within two (2) hours of surface preparation for best results.

The zirconia powder utilized is magnesia stabilized, i.e., with a composition of 76% ZrO_2 and 24% MgO. For applying the plasma coating, a Metco plasma system may be utilized in which the zirconia powder is dried by preheating to 170° F ± 25°F and mixing for 15 minutes. The setter is mounted on a turntable and rotated during deposition. Plasma spraying is done at a power of 1000 Kw (70 volts DC, 500 amps) at a pressure of 100 psig and feed rate of 5pph in an air atmosphere. The stabilized zirconia is deposited by the high energy plasma spray in one pass to a uniform thickness of approximately 0.0015 in., and within a range of 0.001-0.0035 in. The plasma coated alumina substrate is then rubbed lightly with 200 grit sandpaper to produce a smooth finish.

A ceramic-based electronic component is then placed on the plasma coated, zirconia-clad alumina setter and inserted into a conventional heat treating furnace and heated to a temperature of 1100-1400°C in air for 2 hours.

Likewise, a magnesia-clad setter utilizing the aforedescribed compositions of magnesia powder may be made and used to fire a ceramic-based component in a similar manner as described above.

The finished plasma sprayed zirconia or magnesia coating on the furnace fixture of alumina or other substrate allows users to benefit by the resistance of the zirconia or magnesia cladding layer to reaction and contamination which allows extended time between replacement and elimination or lessening of sticking problems with the ceramic-based components. The system of the present invention has been tested and proven reliable for many electronic and non-electronic components. The zirconia cladding has been found to be especially useful when firing ferrite, titanite, nickel manganate ($NiO{\cdot}MnO_2$), zirconia and yttria ceramic components. The titanates include sensitive barium titanate and magnesium titanate electronic components. The magnesia cladding is useful in firing lead compounds (e.g., lead oxide, lead non-oxides, lead zirconium titanates, lead titanates, lead metaniobates), ferrous oxide compounds (e.g., non-magnetic compounds, including those in mixture or compound with Zn and/or Mn) and beryllium compounds (e.g., BeO). Thinner cross sections of the composite zirconia- or magnesia-clad substrate may be utilized than with monolithic zirconia or magnesia and with a greater flatness for increased furnace capacity. As compared to monolithic zirconia or magnesia, the increased thermal conductivity of alumina body combined with the overall lower mass will yield a faster ramp up and down from firing temperatures.

It will thus be seen that the objects set forth above, among those made apparent from the preceding description, are efficiently attained and, since certain changes may be made in the above constructions without departing from the spirit and scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

While the invention has been illustrated and described in what are considered to be the most practical and preferred embodiments, it will be recognized that many variations are possible and come within the spirit and scope thereof, the appended claims therefore being entitled to a full range of equivalents.

Claims

1. A method of heat treating ceramic-based components selected from the group consisting of titanates, ferrites, nickel manganate, zirconia, yttria, lead-containing compounds, ferrous oxide-containing compounds and beryllium-containing compounds, said method comprising the steps of:

   a) providing a furnace fixture adapted to support said ceramic-based electronic components comprising a substrate selected from the group consisting of silicon carbide (SiC), cordierite ($2MgO \cdot 2Al2O_3 \cdot 5SiO_2$), mullite ($3Al_2O_3 \cdot 2SiO_2$), stabilized zirconia, magnesium oxide (MgO) and alumina containing a glassy bond phase, said substrate having deposited on at least a portion of a surface thereof a top cladding layer of plasma-deposited zirconia or magnesia;
   b) providing said ceramic-based component;
   c) placing said ceramic-based component on the zirconia- or magnesia-coated portion of said substrate; and
   d) firing said ceramic-based electronic component and zirconia- or magnesia-clad substrate to a desired temperature to heat treat said ceramic-based component.

2. The method of claim 1 wherein said substrate has deposited on at least a portion of a surface thereof a top cladding layer of plasma-deposited zirconia.

3. The method of claim 2 wherein said substrate comprises alumina in an amount no greater than about 98% by weight of said substrate and at least about 2% by weight of an oxide of silicon or an alkali or alkaline earth metal, or combinations thereof.

4. The method of claim 2 wherein said substrate comprises silicon carbide (SiC).

5. The method of claim 2 wherein said substrate comprises stabilized zirconia or magnesium oxide (MgO).

6. The method of claim 2 wherein said substrate comprises cordierite ($2MgO \cdot 2Al2O_3 \cdot 5SiO_2$).

7. The method of claim 2 wherein said substrate comprises mullite ($3Al_2O_3 \cdot 2SiO_2$).

8. The method of claim 1 wherein said substrate has deposited on at least a portion of a surface thereof a top cladding layer of plasma-deposited magnesia.

9. The method of claim 8 wherein said substrate comprises alumina in an amount no greater than about 98% by weight of said substrate and at least about 2% by weight of an oxide of silicon or an alkali or alkaline earth metal, or combinations thereof.

10. The method of claim 8 wherein said substrate comprises silicon carbide (SiC).

11. The method of claim 8 wherein said substrate comprises stabilized zirconia or magnesium oxide (MgO).

12. The method of claim 8 wherein said substrate comprises cordierite ($2MgO \cdot 2Al2O_3 \cdot 5SiO_2$).

13. The method of claim 8 wherein said substrate comprises mullite ($3Al_2O_3 \cdot 2SiO_2$).

14. A system for heat treating ceramic based components comprising a furnace, a furnace fixture adapted to support said components having a substrate selected from the group consisting of silicon carbide (SiC), cordierite ($2MgO \cdot 2Al2O_3 \cdot 5SiO_2$), mullite ($3Al_2O_3 \cdot 2SiO_2$), stabilized zirconia, magnesium oxide (MgO) and alumina containing a glassy bond phase, said substrate being clad on at least a portion of a surface thereof by an impermeable top layer of plasma-deposited zirconia or magnesia; and at least one ceramic-based electronic component on said zirconia- or magnesia-clad portion of said fixture.

15. The system of claim 14 wherein said zirconia or magnesia layer has a thickness of from about 0.0001-0.010 in.

16. The system of claim 14 wherein said substrate comprises alumina in an amount no greater than about 98% by weight of said substrate and at least about 2% by weight of an oxide of silicon or an alkali or alkaline earth metal, or combinations thereof.

17. The system of claim 14 wherein said substrate comprises silicon carbide (SiC).

18. The system of claim 14 wherein said substrate comprises stabilized zirconia or magnesium oxide (MgO).

19. The system of claim 14 wherein said substrate comprises cordierite ($2MgO{\cdot}2Al2O_3{\cdot}5SiO_2$).

20. The system of claim 14 wherein said substrate comprises mullite ($3Al_2O_3{\cdot}2SiO_2$).

21. The system of claim 14 wherein said fixture has a supporting section thickness less than about 0.100 in. and a zirconia layer thickness less than about 0.010 in.

22. A fixture for heat treating ceramic based components comprising a base having an upper surface for supporting said ceramic based component, said base having a substrate selected from the group consisting of silicon carbide (SiC), cordierite ($2MgO{\cdot}2Al2O_3{\cdot}5SiO_2$), mullite ($3Al_2O_3{\cdot}2SiO_2$), stabilized zirconia, magnesium oxide (MgO) and alumina containing a glassy bond phase, said base substrate being clad on at least a portion of said upper surface by an impermeable top layer of plasma-deposited zirconia or magnesia, and a pair of integral side rails on opposite ends of said base and extending above said upper surface, said side rails being spaced and having a height above a top surface of said base greater than the ceramic-based component to be heat treated on said zirconia- or magnesia-clad portion of said fixture.

23. The fixture of claim 22 wherein the thickness of said base is less than 0.100 in.

24. The fixture of claim 22 wherein the thickness of said layer of plasma-deposited zirconia or magnesia is from about 0.0001- 0.010 in.

25. The fixture of claim 22 wherein said rails are also clad with a layer of plasma-deposited zirconia or magnesia.

26. The fixture of claim 22 wherein said substrate comprises alumina in an amount no greater than about 98% by weight of said substrate and at least about 2% by weight of an oxide of silicon or an alkali or alkaline earth metal, or combinations thereof.

27. The fixture of claim 22 wherein said substrate comprises silicon carbide (SiC).

28. The fixture of claim 22 wherein said substrate comprises stabilized zirconia or magnesium oxide (MgO).

29. The fixture of claim 22 wherein said substrate comprises cordierite ($2MgO \cdot 2Al2O_3 \cdot 5SiO_2$).

30. The fixture of claim 22 wherein said substrate comprises mullite ($3Al_2O_3 \cdot 2SiO_2$).

31. The fixture of claim 22 wherein the cladding layer is substantially inert to said ceramic based component and consists essentially of stabilized zirconia.

32. The fixture of claim 22 wherein the cladding layer is substantially inert to said ceramic based component and consists essentially of magnesia.

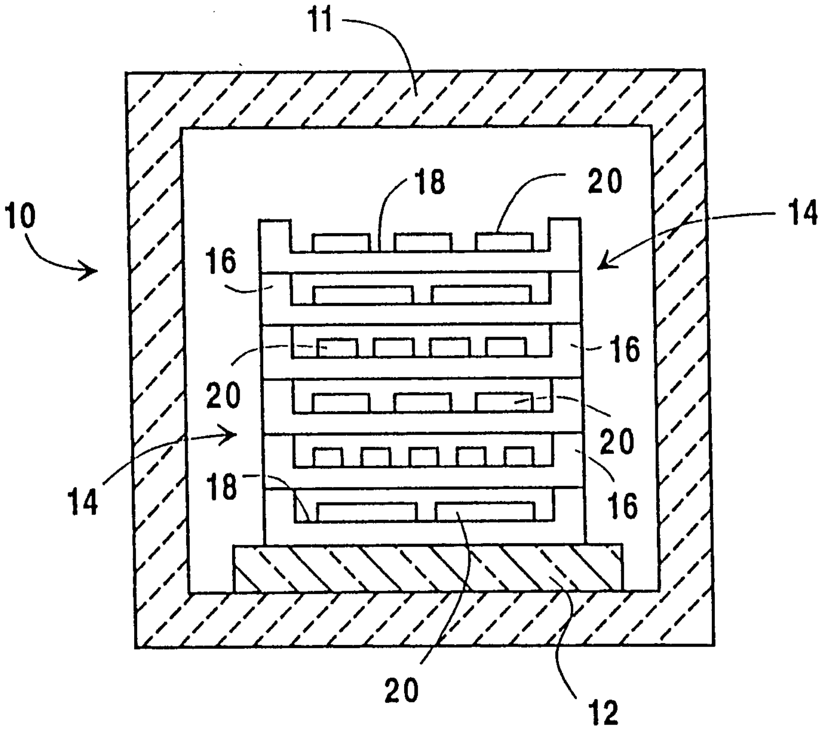

Fig. 1

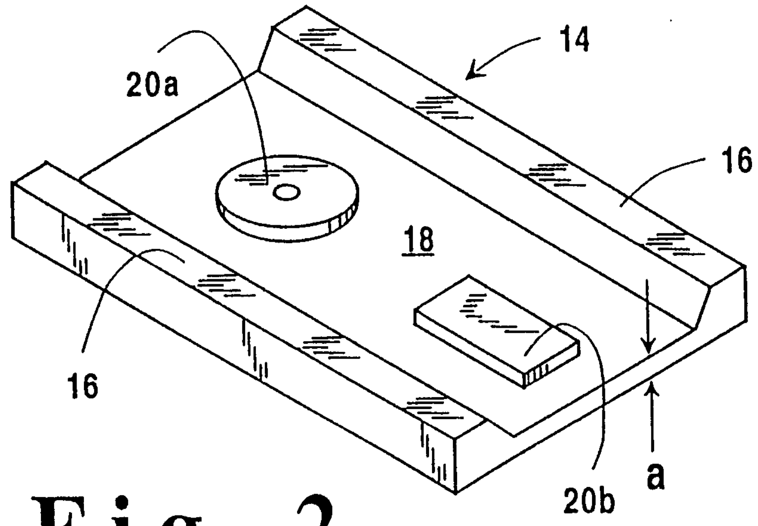

Fig. 2

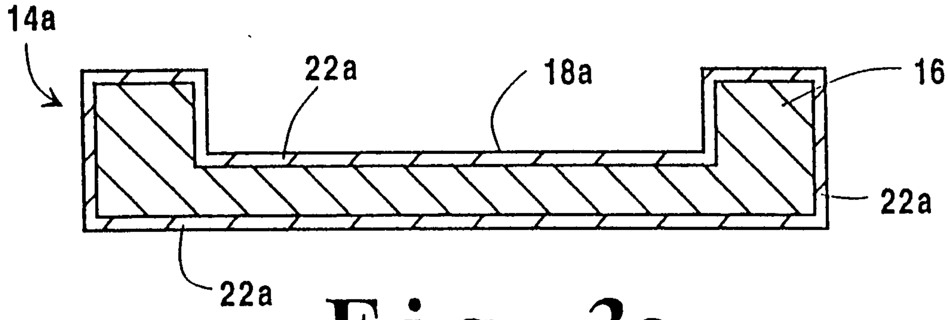

Fig. 3a

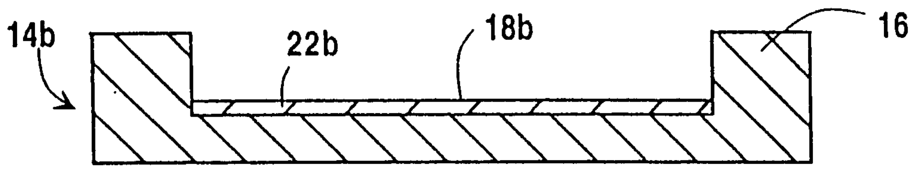

Fig. 3b

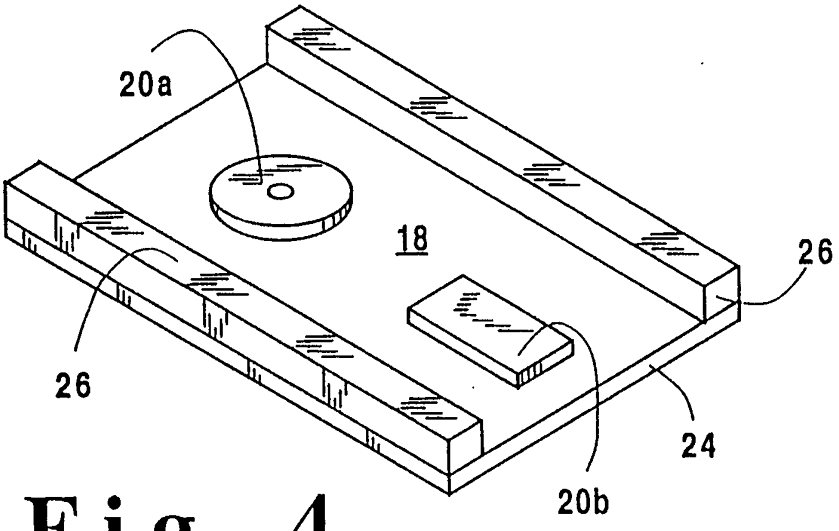

Fig. 4

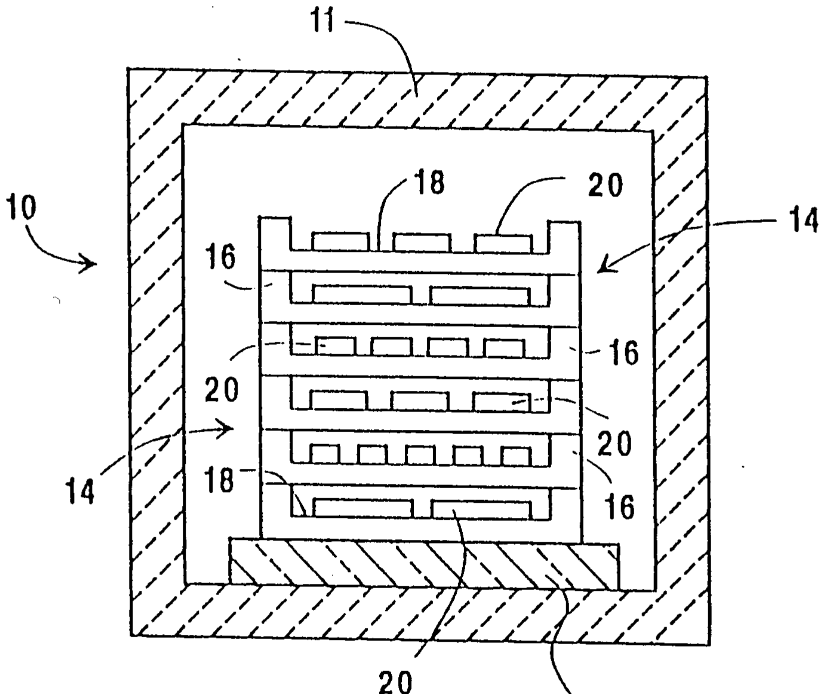

Fig. 1

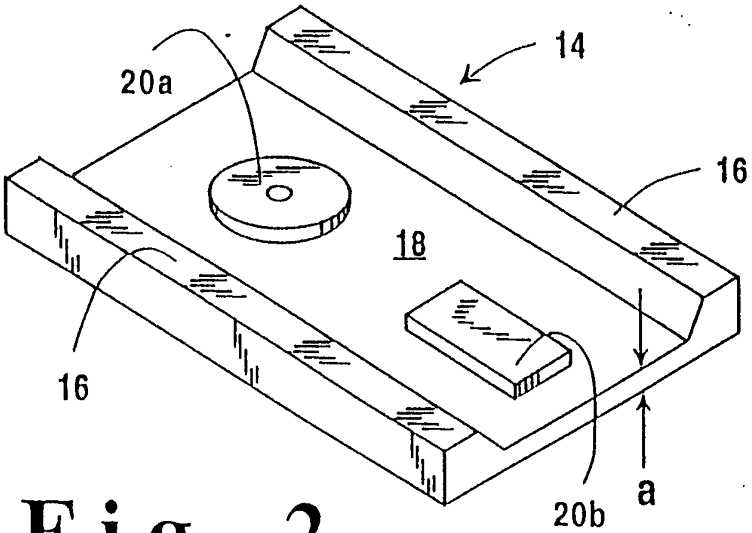

Fig. 2

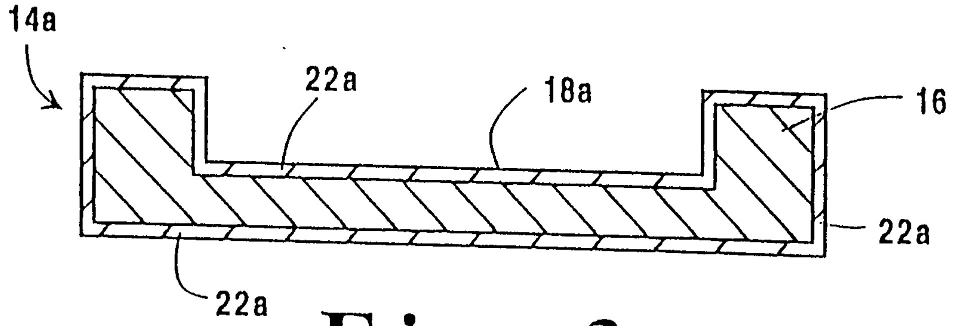

Fig. 3a

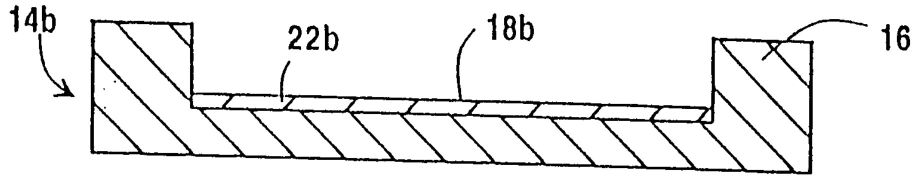

Fig. 3b

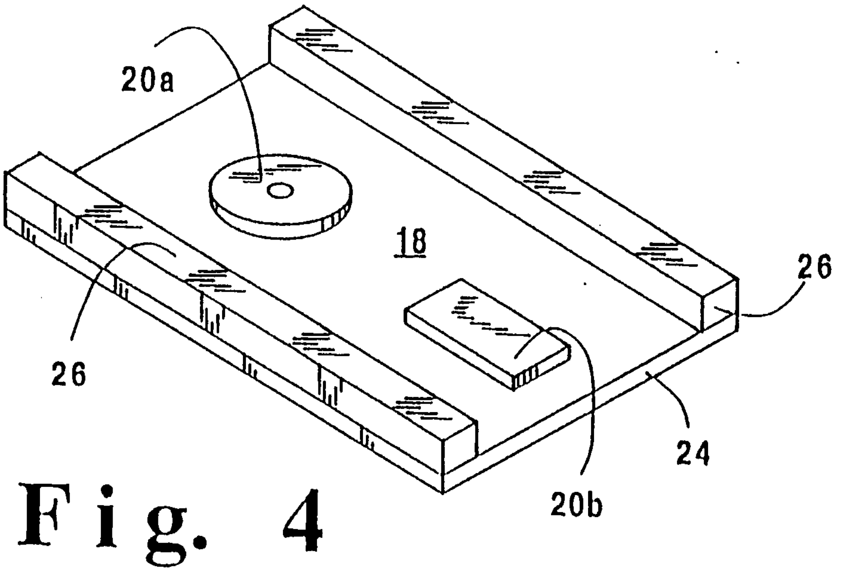

Fig. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/06499

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :B29B 17/00; F27D 5/00
US CL :264/345; 432/258
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 264/57,235,345,346; 432/258

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 4,146,670 (ROGERS) 27 MARCH 1979, abstract.	1-32
Y	US, A, 4,259,061(DUBETSKY) 31 MARCH 1981, col.3, lines 24-41.	1-32
Y	US, A, 4,877,705 (POLIDOR) 31 OCTOBER 1989, col.4, lines 3-39.	1-32
Y	US, A, 4,594,106 (TANAKA ET AL.) 10 JUNE 1986, col.2, line 52-col.3, line 56.	1-32

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:
"A"	document defining the general state of the art which is not considered to be part of particular relevance
"E"	earlier document published on or after the international filing date
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O"	document referring to an oral disclosure, use, exhibition or other means
"P"	document published prior to the international filing date but later than the priority date claimed
"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&"	document member of the same patent family

Date of the actual completion of the international search

07 SEPTEMBER 1994

Date of mailing of the international search report

16 SEP 1994

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