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A NOVEL PROCEDURE TO USE GREEN TAPE AS LOW THICKNESS CERAMIC STRUCTURES

Laura MALATTO, Daniel FILIPPINI, Sergio GWIRC, Liliana FRAIGI

Research Center for Electronics and Informatics Technology
National Institute of Industrial Technology
C.C 157, 1650 San Martín, Buenos Aires, Argentina
Tel: 541 754 4064, Fax: 541 754 5194, e-mail: sensores@inti.edu.ar

ABSTRACT

Microstructures in 3D, which include cavities and micromachined surfaces, have been developed intensively with silicon technology [1,2]. However, the development of such microstructures based on thick film technology has not followed a similar growth pattern. On the other hand, in the last years, new low temperature ceramic materials, Green Tapes (GT), conventionally used for the manufacture of multilayer circuits have been developed.

A new method is presented here, in which the main idea is to use disposable material to support the GT along the firing. Several metallic oxides were used as disposable material and the more successful results were obtained with a deposit of NiO powder. Finally different 3-D geometries of GT free sheets were achieved using special base substrate shapes.

RESUMEN

Microestructuras en 3-D, que incluyen cavidades y superficies micromaquinadas, han sido desarrolladas intensivamente con la tecnología de silicio [1,2]. Sin embargo, el desarrollo de tales estructuras basadas en la tecnología de película gruesa no ha seguido un crecimiento semejante. Por otra parte, en los últimos años se han desarrollado nuevos materiales cerámicos de baja temperatura, Green Tape (GT), que convencionalmente se utilizan para la fabricación de circuitos multicapa.

Un nuevo método se presenta aquí, en el cual la idea principal es usar un material descartable para sustentar al GT durante el sinterizado. Fueron usados varios tipos de óxidos metálicos como material descartable y los resultados más exitosos se obtuvieron con un depósito en polvo de NiO. Finalmente, se lograron diferentes geometrías de hojas libres de GT usando formas especiales del sustrato base.

INTRODUCTION

During the last 10 years, microstructures in 3D, which include cavities and micromachined surfaces, have been developed intensively in silicon technology [1,2]. The development of microstructures based on thick film technology has not followed a similar growth pattern leaving much to be explored in this field. On the other hand, in the last years, new low-temperature ceramic materials, Green Tapes (GT), conventionally used for the manufacture of multilayer circuits have been developed.

The applications of GT materials as very thin structural elements (less than 100μm) is still an unexplored field, presenting very attractive possibilities for obtaining free and homogeneous structures compatible with alumina substrates.

In the standard procedure of GT multilayer circuits several stacked layers which are pressed at 200 bar and heated at 70°C are used. This procedure cannot be applied if one single layer is wanted. In this paper a novel procedure to obtain fired GT as a free sheet is presented.

EXPERIMENTAL AND RESULTS

The main problems that have been solved were: cracking, induced by stress due to unwanted adherence to substrate, and membrane distortion.

The pressures involved in the standard process, that is one of the most critical steps when a thin GT structure is wanted, and the shrinkage of the material (12%) in the firing process make necessary to explore new techniques with the possibility to obtain a 3-D GT framework. The developed method avoid high pressure over the GT sheet, which was the greatest source of cracking during the sintering together with thermal stress, which is specially important to 3-D structure design.

Other aspect to be considered is the stress due to unwanted fixed points produced by sticking of GT and the base. These stress points are developed during shrinkage of the material when it was sintered at high temperature in oxygen atmosphere. Likewise, distortion of GT single free sheet has to be avoided; the layer not only suffer shrinkage on surface directions, also there is a deformation in a third direction perpendicular to the layer.

The developed procedure consist on obtaining the right sticking of GT to a base specially designed, strong enough to avoid distortion and weak enough to allow surface movements. Furthermore, the layer of GT must be free after sintered. This method allows to work·without applying both high pressures and heat before firing.

Koycera type 96% alumina 50x50 mm and 600 µm thick was used for the base. A layer of silver conductor (Hereaus Ag8710) was screen printed over the alumina using 300 mesh stainless steel screens at a 45° angle (Fig. 1a). After the printing process, the base was dried in a convection oven at 120 °C during 10 minutes; it was then sintered in a four zones Lindberg and Blue convection-radiation furnace at a peak temperature of 850 °C during 10 minutes. This conductor layer allows to improve the adhesion of the next one, which is the actual sacrificial layer in contact with the GT.

The sacrificial layer was applied using screen printing technique. A very simple formulation using two components: an organic vehicle and a functional material allowed to obtain this paste. A bitumen was used as organic vehicle, which provide a suspension material for the particles. TiO_2, SnO_2 and NiO metal oxides were used as active material. Powder of metal oxides were mixed with vehicle to obtain a rheology suitable for the printing of the layer.

Once the sacrificial layer was screen printed onto the base of the substrate was heated at 120 °C during 15 minutes in a convection oven in order to spread homogeneously the particles. After a firing at 850°C during 10 minutes a covered surface by a densely distributed powder was obtained.

On the other hand, a silver ink (Heraeus Ag8710) is printed onto a sheet of GT (Fig.1b) and it is immediately attached to the base (Fig.1c). The assembly was dried at 120 °C during 15 minutes and fired at 850 °C peak temperature during 10 minutes. Finally, a layer of GT with metallized surface free of distortion and cracking which is easily detachable from the base was obtained (Fig. 1d).

The better results were obtained using NiO, 0.5µm particle size. The rest of the grain powder adhered to GT metal layer could be cleaned up by means of HCl washout. The same procedures used can be applied to obtain 3-D structure just changing the silver patterns onto the alumina substrate from a flat one to a stacked layers as shown in Fig. 2.

CONCLUSIONS

A novel procedure for a free low temperature GT ceramic substrates, less than 100 µm thick, was obtained.

The possibility to obtain 3-D GT structures which can be used as ceramic substrates of low thickness and thermal conductivity is available through these process.

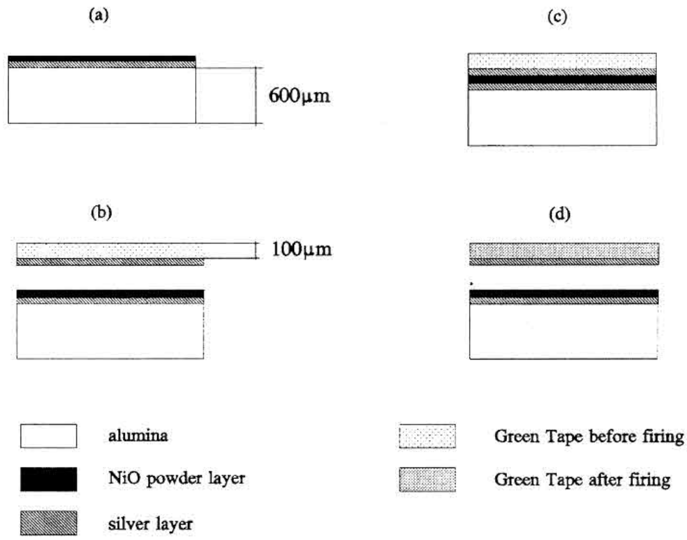

FIGURA 1. Schematic representation of free planar GT layer process. a) conductor and sacrificial layer on the base substrate, b) conductor layer on GT, c) GT and alumina substrate attached before sintering, d) free GT structure after sintering.

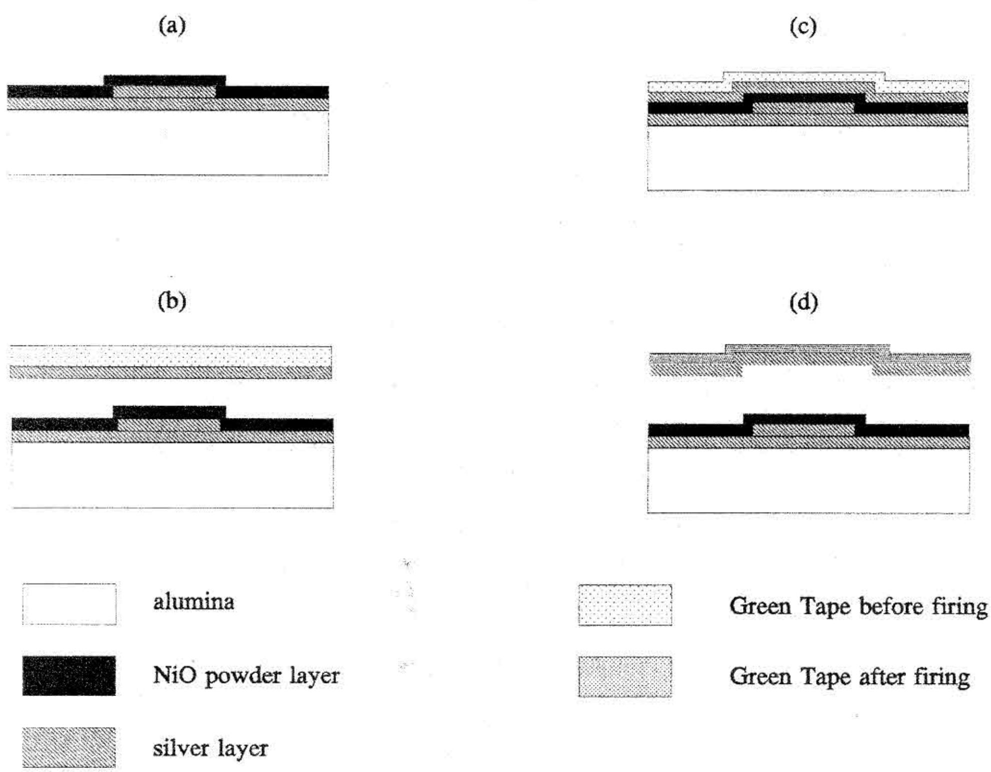

FIGURA 2. Schematic view of 3-D GT structures.

NiO 0.5μm particle size powder was the best disposable material tested, which permits to avoid cracking and distortion in free sheet GT layer during the firing process.

These kind of material have important applications in the measurement of physical and chemical parameters, both in sensors and microstructures field.

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