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High temperature LTCC package for SiC-based gas sensor

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A rapid progress in the development of semiconductor microelectronics is still observed. Miniaturization process of electronic devices is closely connected to packaging issues. In many cases package is as important as the device itself. Low temperature co-fired ceramics (LTCC) and thick-film technologies have the potential of incorporating multilayer structures and permit fabrication of special packaging systems. LTCC technology allows us to connect simply electrical or optical signals and to integrate passive components, heaters, sensors, converters, *etc*. In this paper, an LTCC package for SiC-based hydrogen gas sensor is presented. Some simulations of thermal properties were carried out and package structures were made and investigated. The package protects the sensor against mechanical damage and makes an easy connection of electrical signals possible. Moreover, the heater and temperature sensors allow proper temperature of an element to be obtained. Basic electrical parameters of an integrated heater as well as measured temperature distribution are presented.

Keywords: thick-film, low temperature co-fired ceramics (LTCC), packaging.

1. Introduction

The low temperature co-fired ceramics (LTCC) technology has been used for almost twenty years to produce multichip ceramic modules (MCM-C) – a multilayer substrate for packaging integrated circuits [1–4]. At the beginning, the technology was mostly used for production of high volume microwave devices. Recently, LTCC was also applied for the production of sensors [5] and actuators [6] thanks to its very good electrical and mechanical properties, high reliability and stability as well as possibility of making three-dimensional (3D) integrated microstructures [7, 8]. The LTCC technology is well established both for low volume high performance application (military, space) and high volume low cost application (wireless communication, automotive). A great advantage of LTCC technology is the low temperature of cofiring, which enables us to use standard thick-film materials. A great variety of these materials with different electrical properties are used to make a network of conductive paths in a package and to integrate other electronic components, sensors, actuators, microsystems, cooling and heating systems in one module. LTCC structures become more and more sophisticated. This paper presents fabrication process as well as chosen geometrical, electrical and thermal properties of LTCC package for gas sensor.

2. Package fabrication

The package was produced by a LTCC method [1]. Planar dimensions of the package are 10 mm × 15 mm. The structure consists of four layers made of DP 951 P2 tape. The package crossection is shown in Fig. 1.

Fig. 1. The LTCC package crossection.

The thickness of each layer was 165 μm before firing. Layers 1 and 2 increase the mechanical stability of the package. Meander heater from DP 6146 PdAg based ink and conductive paths from ESL 963 PdAg based ink were screen-printed on layer 3. Electrical connections between pads on the top layer and heater were obtained by vias forming. The vias inside the LTCC tape were cut by Nd-YAG laser (Aurel NAVS 30 laser trimming and cutting system), then they were filled with ESL 963 ink. The termination pads for electrical connection to the heater and for wire-bonding from gas sensor to the package were situated on its surface. After printing the LTCC tapes were stacked in the proper order into one module, pressed in an isostatic press (pressure 20 MPa, temperature 70 °C) and then co-fired in air atmosphere at the typical temperature profile (peak temperature 875 °C). The picture of the fired LTCC package and with sensor chip is shown in Figs. 2**a** and 2**b**, respectively.

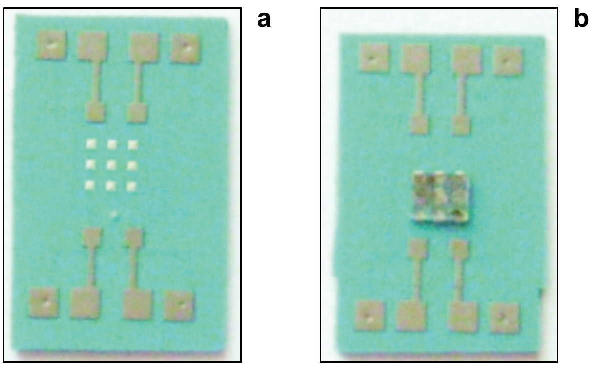

Fig. 2. Top view of the LTCC package (**a**) and with sensor chip (**b**).

3. Results

The electrical parameters of integrated heater were measured. The repeatability of resistance was determined, standard deviation was about 3%. Resistance of the heaters in one series of packages is shown in Fig. 3.

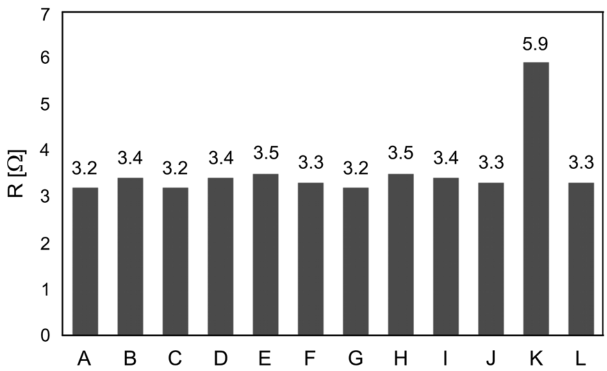

Fig. 3. Resistance of the heaters in a series of packages.

The temperature distribution on the package surface and sensor chip was measured at a steady state. Temperature distribution on the package and sensor for the heating power equal to 1.4 W is presented in Fig. 4.

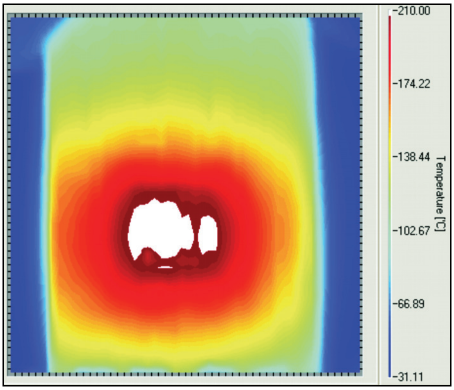

Fig. 4. Temperature distribution on the package surface – heating power 1.4 W.

To obtain the same heat emissivity the package and chip were covered with a black paint. IR scanner determined the temperature distribution on the surface with 2 °C accuracy. The scanning process was carried out with a 2 mm step in *X*:*Y* direction, allowing a proper resolution of the results to be obtained. The temperature distribution on the chip surface was uniform and maximum difference including measurement uncertainty was about 4 °C.

4. Conclusions

The designed and fabricated LTCC package makes it possible to protect sensor chip against mechanical damage and to assembly electrical connections to the chip structure. It provides uniform temperature distribution on the chip surface so that the thermal conditions required for proper work of the device are achieved. Moreover, integrated heaters exhibit good repeatability of their basic parameters.

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