07 - 10 September 2009

PROCEEDINGS

54. IWK

Internationales Wissenschaftliches Kolloquium
International Scientific Colloquium

Information Technology and Electrical Engineering - Devices and Systems, Materials and Technologies for the Future

Faculty of Electrical Engineering and
Information Technology

TECHNISCHE UNIVERSITÄT
ILMENAU

Impressum

Herausgeber: Der Rektor der Technischen Universität Ilmenau
Univ.-Prof. Dr. rer. nat. habil. Dr. h. c. Prof. h. c.
Peter Scharff

Redaktion: Referat Marketing
Andrea Schneider

Fakultät für Elektrotechnik und Informationstechnik
Univ.-Prof. Dr.-Ing. Frank Berger

Redaktionsschluss: 17. August 2009

Technische Realisierung (USB-Flash-Ausgabe):
Institut für Medientechnik an der TU Ilmenau
Dipl.-Ing. Christian Weigel
Dipl.-Ing. Helge Drumm

Technische Realisierung (Online-Ausgabe):
Universitätsbibliothek Ilmenau
ilmedia
Postfach 10 05 65
98684 Ilmenau

Verlag: isle
Verlag ISLE, Betriebsstätte des ISLE e.V.
Werner-von-Siemens-Str. 16
98693 Ilmenau

ISBN (USB-Flash-Ausgabe): 978-3-938843-45-1
ISBN (Druckausgabe der Kurzfassungen): 978-3-938843-44-4

Startseite / Index:
http://www.db-thueringen.de/servlets/DocumentServlet?id=14089

54th Internationales Wissenschaftliches Kolloquium
Ilmenau University of Technology
07 – 11 September 2009

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Aluminium package for temperature sensors

MICRO- AND NANOELECTRONICS

Aluminium alongside with ceramics, steel and other materials is widely used in manufacture of the packages of temperature sensors. Anodic alumina is used in microelectronics as switching boards, multileadout housings to a LSI circuit and VLSI circuit, multicrystalline modules, in electrostatic capturing and anchoring devices of robotics etc. Thermal conductivity, chemical stability, low-cost and other properties of anodic alumina make this material prospective for manufacturing the packages of thermal sensors [1].

In this paper we propose two types of anodic alumina packages: (i) a rectangular packages 4x6x15mm in size (fig. 1) [2], and (ii) a cylindrical package Ø5x15mm in size(fig. 2).

The structural elements of the package (a basis, an insulator and a cover) were made from a leaf- or tape-like aluminium alloy AD-1N the GOST 21631-76 by chemical milling. Then they were anodized for making an insulating layer on a perform surface. The assembly of a package consists from connection to each other the basis, the insulator, and then the cover by using the interleafs derived from a melted polymer (fig. 1).

The hollow cylindrical billet of a case was fabricated by a method of extrusion from a round tablet of a deformable aluminium alloy AMg-2, 4, 6м the GOST 21631-76 of Ø10x10mm in size (fig. 2). Then it was subjected to anodizing for making an insulating coat. Then the chip was mounted into the package. After it the voids were filled with a magnesia, Al_2O_3 etc. to enhance thermal conductivity. Finally, an encapsulant like high-temperature cement, organic silicon glue or glaze was used.

To estimate the efficiency of usage of anodic alumina, the calculations of thermal resistances of different materials, which had been used in manufacturing of the packages of thermal sensors, were performed. According to our calculations of thermal resistance, the aluminium packages coated with the anodic oxide layer 50 microns thick only 1,25 and 2 times worse as compared to beryllium oxide and copper, but 50 times better as widely spread glassceramics and 20 times better as enameled steel substrates.

The method of detection of the microcracks in alumina was developed basing on the measurements of potential of a broken circuit of an aluminium electrode, which depends on the oxide layer thickness[3]. Appearance of microcracks results in a negative shifting of the potential. The examinations of thermal resistance of anodic alumina to cracking revealed its enhancement in a sequence of electrolytes $H_2SO_4 < H_2C_2O_4 < H_3PO_4$. Further, for any of the above electrolyte, thermal resistance of anodic alumina also increases with the rise of the anodizing voltage. Thermal stability of the fabricated packages was tested at a temperature ranging from –50 to +160°C.

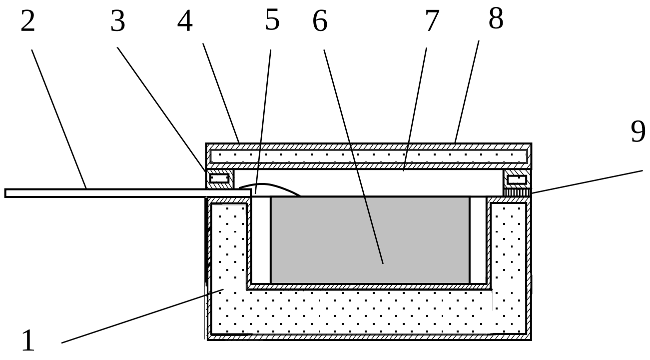

Fig. 1. Design of a temperature sensor in the rectangular aluminium package: 1 – the basis; 2 – package contacts; 3 – insulating strip; 4 – cover; 5 – wiring contacts; 6 – the thermal converter chip; 7 – aluminium; 8 – anodic alumina; 9 – glue film

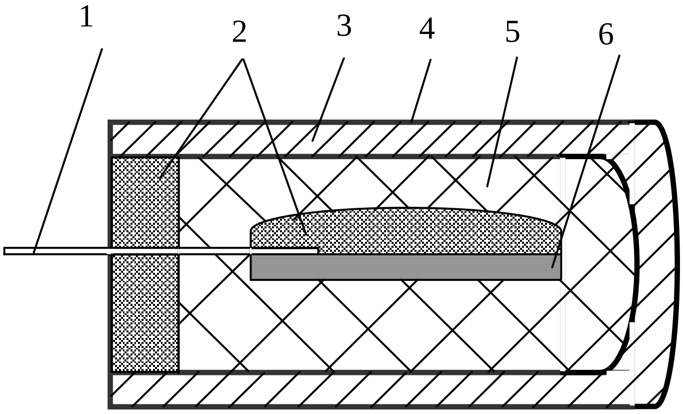

Fig. 2. Design of a temperature sensor in the cylindrical aluminium package: 1 – package contacts; 2 – hermetic; 3 – package (aluminium); 4 – package (anodic alumina); 5 – magnesia; 6 – the thermal converter chip

For the investigation of thermal inertia the thin film aluminum sensors with a standard calibration characteristic R=f(t) were used – Fig.3.

The selected sensors were connected to personal computer through adapter allowing detection of the change of resistivity with time and printing the data as a table or graph. The sensors were put in thermally insulated capacity with hot water (t=50°C). The temperature of water was measured with a calibrated mercury thermometer with an accuracy 0.1°C. Agitation of water was also used.

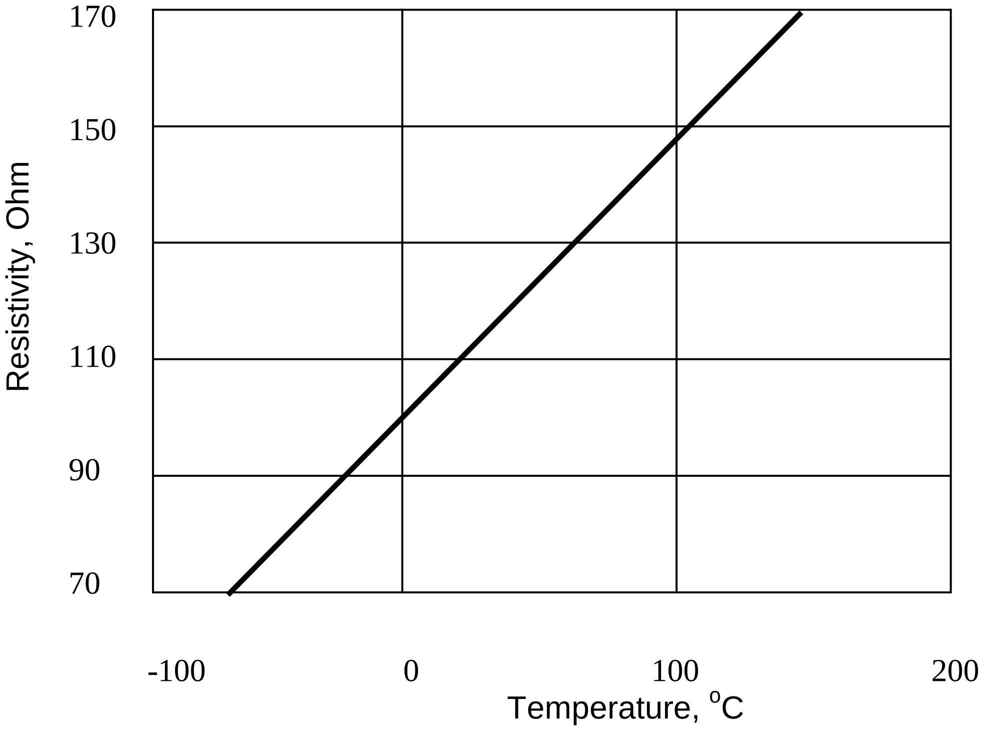

Fig.3. Dependence the changing of the resistivity of thin aliminum transformers from temperature in the range from – 50 to 150°C

Thermal inertia was performed at the level 0.9 from the temperature of water t = 50°C, i.e. at 45°C. Recalculation was performed by determination from the calibration curve the value of resistivity, corresponding to the temperature 45°C (115 Ohm). The value of thermal inertia, corresponding to 45°C or 115 Ohm was detected from the Figs. 4, 5. The obtained values of thermal inertia for the rectangular package $t^{0.9}$ = 106 s, for cylindrical package – 93 s.

The value of thermal inertia in cylindrical package was found to be lower, because the void between the walls of package and the sensor was filled with crystalline alumina, allowing high thermal transport inside the package.

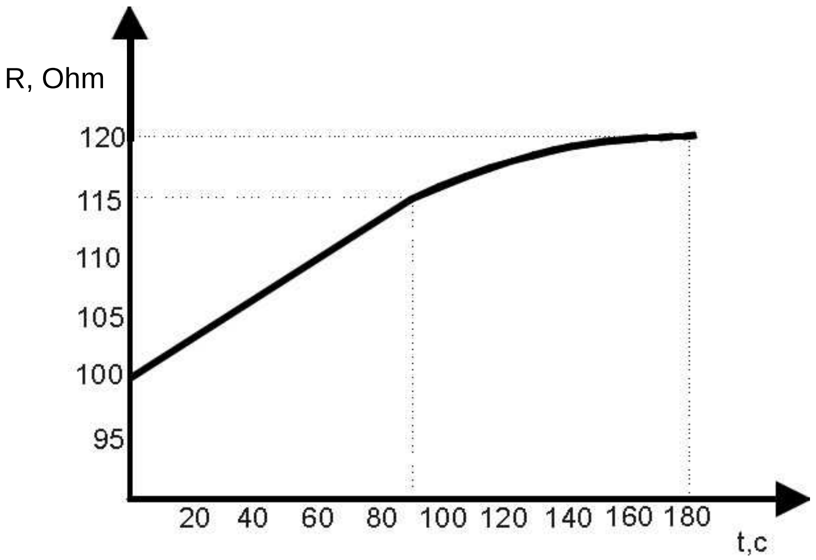

Fig.4. Dependence of resistivity from duration of time for the sensor in cylindrical package

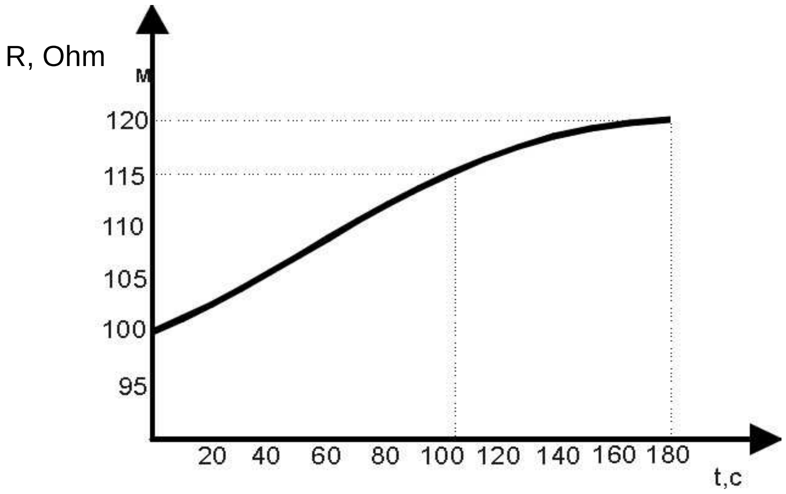

Fig. 5. Dependence of resistivity from duration of time for the sensor in rectangular package

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