# Anodized Aluminum as a Construction Element in Microelectronics

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*Abstract* – **In the present article is revealed a survey on the anodized oxide aluminum implementation in microelectronics. Its application as a dielectric insulator in power hybrid circuits, multilayer MCMs and microwaves is also concerned. Nanostructure matrix application for the development of nanoelements is paid attention to, either. Experimental results of researches in the department of Microelectronics (Construction, technology and production of microelectronic elements) are shown.**

*Keywords* – **anode oxide, microelectronics**

## I. Introduction

In up-to-date electronics, one of the basic trends is device miniaturization. Common element in one electronic product is the PCB or speaking generally – the electronic carrier. The parameters of typical carriers are dealt with in [1]. Except the widely-spread and known materials on the base of epoxy and glass-fiber for high power device applications, MCMs and microwaves, different options could be used. For example, in hybrid circuits with high power dissipation on ceramics, metal substrates with insulator layers deposition may be employed [2]. Specific requirements are stated for the module carriers working at high frequencies [3], where one of the main parameters is the dielectric material permittivity. In the last years, silicon technologies for such carriers are developed, the so called "assembly on silicon" [4].

One of the successful carrier materials having implementation in the whole spectrum of devices is the aluminum, moreover its different variants of anodization [5]. In the present paper are considered technology approaches, developed at the department "Microelectronics" for more than 20 years.

## II. Anodic Oxides of Aluminum

### A. Production technology

The aluminum anodization is a technology known for decades. Characteristic feature of the anodic oxide growth is exothermal nature of the process. While most of electrolytes are not chemically aggressive and do not require special basin materials, the exothermal feature demands special basin constructions. In table 1 are given some examples of the typical anodization electrolytes and the achieved ratio - pores diameter/cell diameter.

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TABLE I
ALUMINUM ANODIZATION ELECTROLYTES

| Electrolyte | J=30A/м2 | | | α |
|---|---|---|---|---|
| | pH | Uст.B | ta min. | |
| H2SO4(5%) | 0,5 | 12,3 | 19,7 | 0,326 |
| H2SO4(10%) | 1,0 | 15,4 | 19,6 | 0,319 |
| (COOH)2(2%) | 1,8 | 33 | 19,7 | 0,326 |
| H3PO4(4%) | 1,3 | 48 | 19,6 | 0,319 |

The achievement of constant and guaranteed parameters requires support of a determined process temperature. This demands heat dissipation and necessity of thermostatic basin. Reaching of high oxide density imposes work with electrolyte at temperature of 3-5˚C.

### B. Parameters as an insulation layer

According to the applications, attention is paid to the dielectric permittivity, losses and strength of the oxide. The permittivity and losses are predominant in high frequency applications. The dielectric characteristics of the amorphous and polycrystalline aluminum oxide are investigated in a broad frequency band (1 kHz…16 GHz) and heating up to 100°C. On Fig. 2 are depicted the characteristics of the oxide as an insulator.

The feature of the obtained dependencies is mostly for polycrystalline aluminum oxide and qualifiedly coincides with the frequency properties of inorganic dielectrics absorbing water.

When applying procedures for tightening or filling of the oxide pores, the dielectric strength might be controlled. Technologically, at thicknesses of 300um one could achieve break-down voltage of 700V.

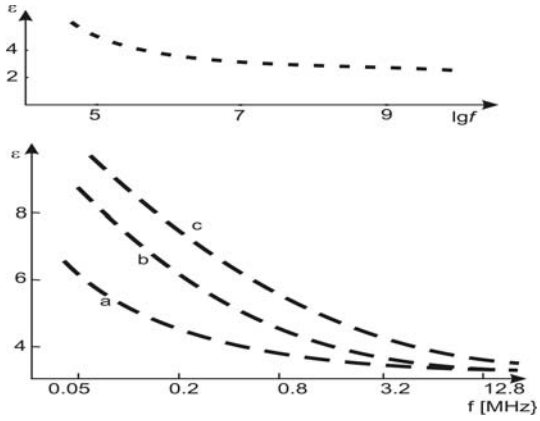



Fig. 1 Dielectric permittivity of anodic oxide vrs. temperature: - a.) 20˚C, b.) 60˚C, c.) 80˚C

### C. Nanostructure grid

Characteristic of oxide growth is the presence of pore structures with pore diameters in the range of tens to hundreds nanometers. On Fig. 2 is shown pores type of the oxide.

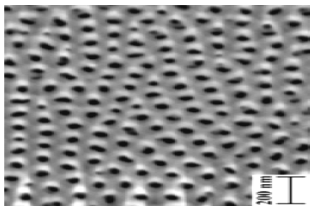


Fig. 2 Structure of anodic Al2O3

## III. CONSTRUCTION APPLICATIONS

### *A. Isolation layer in hybrid circuits and modules.*

The possibility of own oxide growth is extremely appropriate in the development of multilayer systems with conductive and dielectric elements in MCMs. According to the oxide thickness, the same could be used as an insulator or capacitor element in Fig. 3.

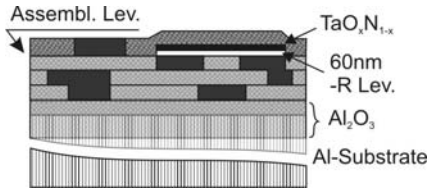


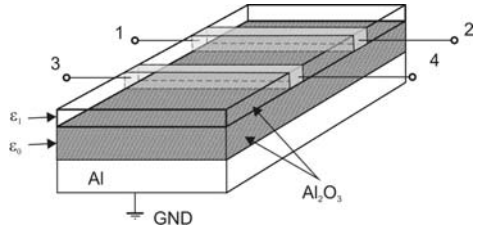

Fig.3 Vertical MCM structure.

### *B. Power modules*

The proper combination of mechanical parameters and comparatively good thermal conductivity allow the anodic oxide to be implemented as a dielectric in elements with great heat loading. For example in power light emitting diodes and heating elements such construction permits effective heat dissipation [6].

### C. *Microwave applications*

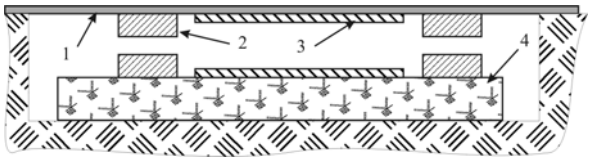
According to the pores density and filling with different materials, the dielectric permittivity and losses in the layer could be controlled. Combining technology routes with different dielectrics, the development of various microwave elements is achievable. On Fig. 4 are shown embedded microstrip lines.




Фиг. 4 Microstrip microwave element.

### *D. Micromechanics*

The anodic oxide could be a construction element in the micromechanics. Application example of electrostatic relay is given on Fig. 5.




Фиг. 5 Electrostatic relay (principle)

Onto deformable (elastic) joist 1 of anodic oxide are deposited contact elements 2. The similar are disposed on the relay base 4. The electrodes 3 are the electrostatic elements. When applying opposite potential the latter are attracted and close the contact circuit.

## IV. CONCLUSION

The aluminum, together with its own oxide, are constructive materials allowing the development of passive electronic modules in the whole frequency band in practice. The good thermal conductivity and dielectric strength are precondition of its application in power modules.

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