

# MATERIAŁY

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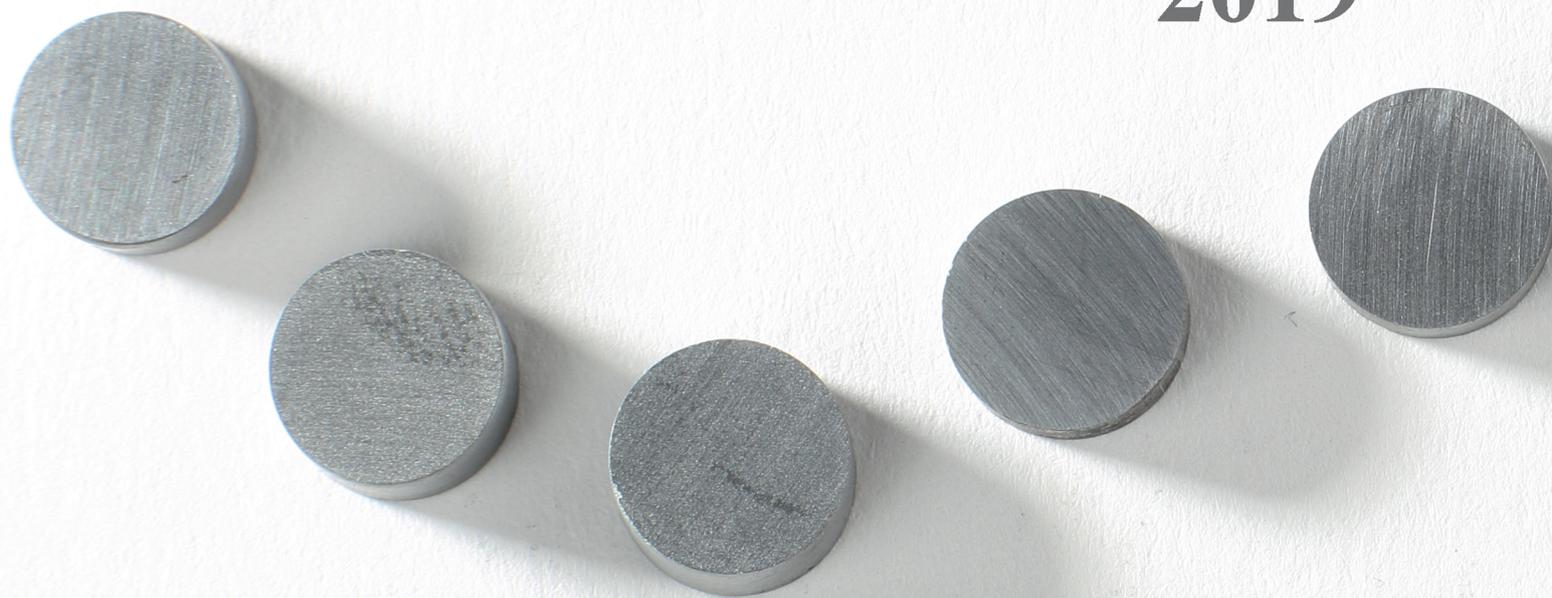
# ELEKTRONICZNE

## ELECTRONIC MATERIALS

# 1-4

Vol. 47

2019



# 40 YEARS OF ITME

SIEĆ BADAWCZA  
ŁUKASIEWICZ



INSTYTUT TECHNOLOGII MATERIAŁÓW ELEKTRONICZNYCH  
INSTITUTE OF ELECTRONIC MATERIALS TECHNOLOGY

ŁUKASIEWICZ RESEARCH NETWORK  
INSTITUTE OF ELECTRONIC MATERIALS TECHNOLOGY

**MATERIAŁY  
ELEKTRONICZNE**  
ELECTRONIC MATERIALS

**QUARTERLY**

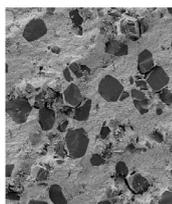
**Vol. 47, No. 1 - 4  
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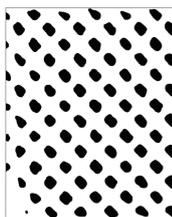
WARSAW ŁUKASIEWICZ – ITME 2019

## CONTENTS **4** Influence of the rigid alumina particles added to ZrO<sub>2</sub> ceramics stabilized with Y<sub>2</sub>O<sub>3</sub> for its mechanical properties



The effect of the phase added to ZrO<sub>2</sub> ceramics on its mechanical properties, mainly its fracture toughness, was examined using the example of Al<sub>2</sub>O<sub>3</sub> - ZrO<sub>2</sub> composite where ZrO<sub>2</sub> was stabilized with 3 mol% of Y<sub>2</sub>O<sub>3</sub>. Composites of 20% wt. Al<sub>2</sub>O<sub>3</sub> - 80 wt.% ZrO<sub>2</sub> differing in the size of corundum grain were made. Vickers indenter crack resistance tests showed an increase of 21% in the value of this parameter for samples with Al<sub>2</sub>O<sub>3</sub> grains of approx. 6.5 μm in comparison with pure ZrO<sub>2</sub> ceramics. On the basis of literature data and own microscopic observations, a thesis was made that this increase is caused by two factors, i.e. the increase of the phase transition range (from tetragonal to monoclinic phase) accompanying crack propagation and the effect of large Al<sub>2</sub>O<sub>3</sub> grains as bridges fastening the fracture surfaces.

M. Boniecki  
P. Gołębiowski  
H. Węglarz  
A. Piątkowska  
M. Romaniec  
K. Krzyżak



## **15** Porous volumetric structures obtained by additive manufacturing technologies

The goal of our work was to develop bulk structures characterized by a variable, controlled porosity, using additive manufacturing techniques (3D printing). A technology for the fabrication of bulk materials with controllable porosity has been developed. For that purpose, the samples with constant porosity were designed and then prepared, which allowed us to learn the possible limit values. Thus, we were able to optimize the design process at the stage of the preparation of the gradient structures.

K. Kaszyca  
W. Danilczuk  
R. Zybala

## **23** 40 years of the Institute of Electronic Materials Technology

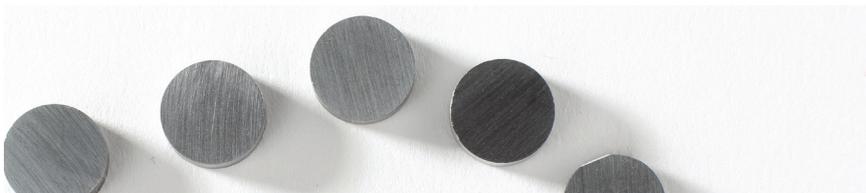
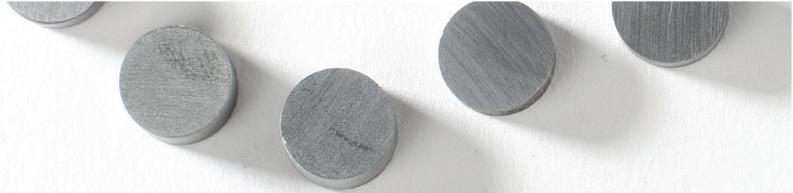
P. Skoczek  
S. Plasota

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**On the cover:**

Ag-C composites developed as a part of the GRAMCOM project.

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The *Institute of Electronic Materials Technology* develops advanced innovative production technologies of materials characterized by a perfect crystallographic structure and excellent properties, as well as components based on these materials. The scope of R&D activities carried out covers the following areas:

### Materials for next-generation components:

- graphene;
- topological insulators;
- materials for spintronics;
- self-organising materials;
- photonic crystals, including plasmonic materials and metamaterials.

### Materials for energy generation, storage and transfer:

- wide gap semiconductors, including silicon carbide for GaN HEMT transistors;
- semiconductor-doped glass optical fibres for photovoltaics;
- eutectic materials for photovoltaics;
- SiC wafers and SiC epitaxial layers;
- glass-ceramic seals for fuel cells;
- thermoelectric materials;
- inert matrices for a safe storage of radioactive waste;
- electrode materials for lithium ion batteries;
- ceramic-metal composites and FGMs.

### Materials for photonics:

- materials for III-V based semiconductor lasers (obtained using GaAsP, InGaP, AlGaAs, GaAs, GaSb and InP), wafers, epitaxial structures;
- GaN-based epitaxial structures;
- materials for solid state lasers, produced using strontium-calcium niobate;
- infrared photodetectors and UV photodetectors;
- oxide crystals for lasers, passive Q modulators, scintillators, electro-optical and piezoelectric devices, substrates for superconducting HTSc layers;
- glass and ceramics with carefully designed spectral characteristics, including transparent ceramics;
- diffractive optical elements and microlenses;
- nanostructured thin layers;
- luminescent nanopowders and nanocrystals;
- optical fibres and waveguides, including active and photonic fibres.

### Materials for electronics:

- silicon monocrystals (standard Si wafers and Si wafers with special properties);
- porous silicon;
- silicon foils;
- epitaxial layers on silicon;
- SiC wafers and SiC epitaxial layers;
- nanopowders and polymer-based powders, pastes and inks for printed electronics;
- photosensitive pastes;
- piezoelectric crystals;
- ceramic-metal composites;
- super-pure metals.

### Components:

ITME has elaborated a great number of innovative electronic components based on the manufactured materials, for instance:

- optical fibres (active and photonic), filters, diffractive lenses, two-dimensional photonic microstructures;
- passive elements on membranes (sensors);
- filters, resonators, sensors and actuators based on surface acoustic waves;
- semiconductor devices (lasers, transistors, photodetectors, Schottky diodes);
- solid state lasers and microlasers.

The manufacture of state of the art components is possible at ITME due to high-tech equipment enabling:

- design and manufacture of masks;
- deposition of dielectric thin films ( $\text{SiO}_2$ ,  $\text{Si}_3\text{N}_4$ , AlN);
- multilayer metallization;
- use of lithography: contact printing using deep UV, electron beam pattern generation;
- application of various etching techniques, including reactive ion etching and controlled sidewall etching.

### Advanced methods of material properties investigation:

The characterization of materials is performed at ITME by the following methods:

- standard chemical analysis and spectral instrumental methods (flame atomic emission spectrometry, atomic absorption spectroscopy, ultraviolet to far-infrared spectroscopy);
- Mössbauer spectroscopy (conventional, conversion electron method, X radiation method and unique "Mössbauer" method developed at ITME);
- X-ray powder diffraction using the Rietveld method, High Resolution X-ray diffraction, X-ray reflectometry and X-ray diffraction topography;
- scanning electron microscopy and a method based on synchrotron radiation;
- electron paramagnetic resonance;
- atomic force microscopy;
- standard thermal methods (high-temperature microscopy, thermogravimetry, differential thermal analysis, dilatometry, etc.) and X-ray methods;
- mechanical methods (testing resistance, friction, hardness, etc.);
- optical methods (microscopy, absorption, reflectometry).

### Methods of electronic and photonic components investigation:

ITME tests optoelectronic, microelectronic and piezoelectric devices, using special techniques enabling the characterization of components, including:

- I-V and C-V measurements;
- deep level transient spectroscopy;
- impedance measurements and the measurements of scattering matrix elements up to the frequency of 20 GHz;
- noise measurements;
- analysis of operational parameters of lasers and photodetectors.