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ŁUKASIEWICZ RESEARCH NETWORK  
INSTITUTE OF ELECTRONIC MATERIALS TECHNOLOGY

**MATERIAŁY  
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ELECTRONIC MATERIALS**

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WARSAW ŁUKASIEWICZ – ITME 2020

## CONTENTS **4** Hazards of electromagnetic radiation

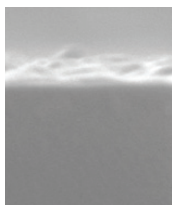
A. Jeleński



After a brief overview of the nature of electromagnetic (EM) radiation and its sources, the selected findings are presented concerning the risks caused by low-frequency EM fields emitted by 50 Hz high-voltage power lines and home appliances. These sources affect mainly the nervous system and may contribute to cancer development. On the other hand, the impact of high frequency EM fields emitted by radio and television transmitters, and mobile phones originate mainly from dielectric losses leading to body heating (thermal hazards) as well as from some athermal hazards, which have been less extensively investigated. The latter effects include: auditory and behavioural effects, blood-brain barrier disruption and cancer. The examples of the recommendations and standards developed by international and national organizations are also presented.

## **15** Determination of the thickness of BN layers on the $\text{Al}_2\text{O}_3$ substrate by FT-IR spectroscopy

M. Możdżonek  
P.A. Caban  
J. Gaca  
M. Wójcik  
A. Piątkowska



Hexagonal boron nitride (h-BN) is an attractive material for applications in electronics. The technology of devices based on BN requires non-destructive and fast methods of controlling the parameters of the produced layers. Boron nitride layers of different thickness were grown on sapphire substrates ( $\text{Al}_2\text{O}_3$ ) using the MOCVD method. The obtained films were characterized by FT-IR spectroscopy using IRR and ATR techniques and by the XRR and SEM methods. We showed that by analyzing the ATR or reflectance spectrum in the range of 600-2500  $\text{cm}^{-1}$  we can measure the thickness of a BN layer on the  $\text{Al}_2\text{O}_3$  substrate. Our measuring method allows measuring the layers with a thickness from ~2 nm to approx. 20 nm.

## **21** The Institute of Electronic Materials Technology in SCIMAGO Ranking in years 2014-2020

J. Sarnecki  
S. Plasota  
A. Jeleński



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**On the cover:**  
lenses made of gallium phosphide (GaP), concave and convex



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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.