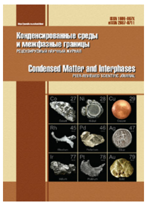

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## Special Issue

# New materials for micro-, nano-, and optoelectronics: properties, structure, and growth mechanisms

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Special Issue No. 4 of the Condensed Matter and Interphases journal covers a wide range of topics related to fundamental and applied aspects of the synthesis and properties of bulk crystals, thin films, whiskers, and 2D structures of new materials already used in micro-, nano-, and optoelectronics and those with very distant application prospects.

Currently, the majority of electronic devices are based on silicon. Silicon remains a fundamental material in the electronics industry. However, modern life requires an ever-increasing variety of devices that cannot be produced using only silicon for several reasons. First, silicon, as a semiconductor material, does not exhibit the desired physical properties. Second, it is only suitable for a certain range of devices, for example, silicon has an indirect bandgap, so it cannot be used to produce LEDs, lasers, etc. Moreover, silicon is not resistant to radioactive radiation, therefore, devices based on it cannot operate stably in high-radiation environments, such as outer space and nuclear power plants. In addition, devices produced using silicon cannot operate at high temperatures, and therefore require cooling. Silicon has several other unavoidable disadvantages.

Modern life and the market require the creation of LEDs, semiconductor lasers, high electron mobility transistors (HEMT), gas control sensors and transmitters, microwave devices, next-generation pyro- and piezo sensors, optical switches, devices that emit and receive terahertz radiation, etc. Nowadays, there is also an urgent need for LEDs that emit hard ultraviolet radiation as well as ultraviolet radiation sensors.

For this reason, we are currently focusing on the search for materials that can at least partially replace silicon,. Such semiconductor materials include wide bandgap semiconductors: silicon carbide (SiC), gallium nitride (GaN), aluminium nitride (AlN), gallium oxide ($Ga_2O_3$), their solid solutions, and a number of other materials. These semiconductors have excellent electrical characteristics and can ensure the operation of electronic and optoelectronic devices at elevated temperatures and under high radiation. Semiconductor materials, such as SiC, AlN, GaN, and $Ga_2O_3$, have wide bandgap. For example, gallium oxide is a new promising wide bandgap semiconductor with a bandgap $E_g \approx 4.9$ eV. This material has several physical properties that make it competitive with silicon carbide and III-nitrides. First of all, it is transparent in the UV spectrum and has a high breakdown voltage (8 MV/cm). In addition, $Ga_2O_3$ can be doped quite easily, which makes it possible to obtain highly conductive layers of this material. Zinc oxide (ZnO) is also a promising semiconductor owing to its potential use in thin-film transistors, LEDs,

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lasers, and photodetectors. It is a direct-bandgap semiconductor with a bandgap of 3.4 eV.

Ferroelectric materials are also of particular interest to researchers. They are widely used in high-speed elements for static and dynamic memory, microelectromechanical systems (MEMS), infrared technology (IR), microwave electronics, piezoelectronics, and other modern high-tech devices. The main ferroelectric materials used in most chips and devices are solid solutions of lead zirconium titanate $Pb(Ti,Zr)O_3$.

In recent years, progress has been made in research on the growth and application of nanowhiskers of various compounds. Such structures have cross-sectional dimensions of 10-100 nm, and their length exceeds their diameter by an order of magnitude or more. Semiconductor nanowhiskers are promising for applications in microelectronics and optoelectronics, as well as in many other fields, such as cantilevers for probe microscopes, gas analyzers, etc. These nanowhiskers can be used to design field-effect transistors, photovoltaic cells, light-emitting elements, and other functional nanodevices.

Undoubtedly, diamond is one of the most promising materials for electronic devices, as it has a combination of the most important physical parameters. The electron mobility in diamond is about 2200 $cm^2/V \cdot c$, and the breakdown field reaches 107 V/cm. Diamond is chemically stable and insoluble in hydrofluoric, hydrochloric, sulfuric, and nitric acids. Diamond has the highest thermal conductivity of all known materials, about 22 W/cm·K at room temperature. Therefore, diamond can be a “perfect” heat-dissipating dielectric substrate. It is transparent over a wide spectral range (from ultraviolet to radio waves), has high hardness (81–100 GPa), and high sound velocity (18 km/s). Owing to these unique properties, diamond is promising for use as a heat sink in electronic devices. Diamond could also be widely used in the manufacture of high-power gyrotron and laser windows, as well as in the manufacture of various types of surface acoustic wave filters operating in the GHz range, and ionizing radiation detectors.

Graphene is expected to be a serious competitor to silicon for use in electronics in the future. It is most likely that graphene will be used in transistors to replace current metal electrodes, as the contact layer thickness in graphene is only 0.34 nm. However, to date, graphene-based devices are still a distant prospect. Indeed, it is not yet possible to grow graphene wafers of a large size, and it is very difficult to control the conductivity of the graphene layers. In particular, the methods for producing semiconductors from graphene are still underdeveloped. Graphene is primarily used only as a conductor or insulator.

Boron nitride (BN) is another new, little-studied material. Thin, one-atom-thick layers of BN could be used in flexible electronics together with graphene. BN is an insulator with an energy bandgap of about 6 eV, whereas graphene exhibits metalloid properties. However, research on this material is still in its infancy.

For spintronic applications, various composite structures based on semiconductor and magnetic materials are of interest.

The editorial board of Condensed Matter and Interphases welcomes researchers engaged in the design of new materials and the study of their properties to share their results with the scientific community by publishing their articles in the special issue of the journal.