PL-1.4

New Areas of Research and Applications for GaN

Ion Tiginyanu
Academy of Sciences and Technical University of Moldova, Chisinau, Republic of Moldova
E-MAIL: *tiginyanu@asm.md*

Gallium nitride, a wide-bandgap semiconductor compound (E_g = 3.4 eV at 300 K), has in the last two decades registered a fascinating increase in the crystalline quality of epitaxial layers determining its leading role in the development of the modern solid-state lighting industry. Exhibiting an impressive number of unique properties such as high breakdown voltage, high switching frequencies, enhanced power efficiency, high electrical conductivity, excellent thermal stability and radiation hardness, over the last decade GaN has been remarkably successful in the area of high-power/high-frequency electronic applications and is now considered the second most important semiconductor material after Si. In this paper, we report on new fields of research and applications of gallium nitride.

First, we describe the possibility to fabricate ultrathin GaN suspended membranes for multifunctional applications. In particular, these suspended membranes were used to fabricate networks of memristor devices exhibiting basic learning mechanisms such as habituation and dishabituation to a certain electrical stimulus [1].

Second, we report on GaN biocompatibility and on possibility to mark living cells with hollow GaN nanoparticles exhibiting piezoelectric and magnetic properties. We show that the living cells marked by GaN:Fe nanoparticles can be guided in a controlled fashion using applied magnetic fields which is important for use in cell therapy [2].

Third, we report on three-dimensional nanoarchitectures of GaN for nano/microfluidic, microrobotic and biomedical applications. The three-dimensional nanoarchitectures are based on GaN micro-tubular structures with nanoscopic thin walls which exhibit dual hydrophobic-hydrophilic behaviour [3]. The micro-tubular structures are shown to self-organize when interacting with water, forming self-healing waterproof rafts with impressive cargo capabilities (cargo up to 500 times heavier than the floating raft). Along with this, we demonstrate self-propelled liquid marbles with exceptional mechanical robustness which may find applications as bioreactors for scalable *in vitro* cell growth. The physical properties of the new material based on three-dimensional GaN architectures will be presented in the context of its prospects for various biomimetic applications. Along with this, the novel material is shown to exhibit shielding capabilities against electromagnetic radiation in X-band [4].

We will discuss the feasibility to use the nano/microtubular structures on GaN for the fabrication of light-driven nano/microengines with performances higher than those inherent to microengines based on arrays of TiO_2 nanotubes [5].

References

1. M. Dragoman, I. Tiginyanu *et al*, Learning mechanisms in memristor networks based on GaN nanomembranes, J. Appl. Phys. 124, 152110 (2018).
2. T. Braniste, I. Tiginyanu *et al*, Targeting endothelial cells with multifunctional GaN/Fe nanoparticles. Nanoscale Res. Lett. **12**, 486 (2017).
3. I. Tiginyanu, T. Braniste *et al*, Self-organized and self-propelled aero-GaN with dual hydrophilic-hydrophobic properties. Nano Energy **56**, 759 (2019).
4. M. Dragoman, T. Braniste *et al*, Electromagnetic interference shielding in X-band with aero-GaN. Nanotechnology **30**, 34LT01 (2019).
5. M. Enachi, M. Guix *et al*, Light-induced motion of microengines based on microarrays of TiO_2 nanotubes, Small **12**, 5497 (2016).