

# FLEXIBLE ARCHITECTURES OF SOLID-STATE ELECTRONIC AND PHOTONIC NANOMATERIALS

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Modern electronics and photonics require fast development of flexible, i.e. bendable, stretchable and conformable components and their networks. Both top-down and bottom-up technological approaches are used to fabricate flexible materials. Highly porous nanomaterials and three-dimensional lightweight architectures consisting of specially-designed networks of nanowires, nanotubes, nanomembranes etc. are among flexible nanomaterials. In this report we will present novel flexible architectures based on ultrathin membranes, nanotubes and microtubes with nanometer-scale wall thickness as well as on hybrid nanomaterials consisting of semiconductor nanodots or nanocrystalline layers deposited on graphene aerogels and aerographite.

Using the approach of surface charge lithography comprising low-dose focused ion beam direct writing of surface negative charge and subsequent photoelectrochemical etching, we demonstrated the possibility to fabricate nanometer-scale thick membranes of gallium nitride, both continuous and nanoporated in a pre-defined ordered fashion [1]. Flexible photonic crystals with embedded waveguides, beam splitters and cavities have been realized. Besides, the proposed technological route enabled one to develop high-power memristive devices based on arrays of ultrathin GaN membranes [2].

Spatial geometry engineering of nano/micro-tubes allows one to vary the surface-to-volume ratio along the tube axis, thus opening new avenues for practical applications. In particular, arrays of titania nanotubes with conical internal shape are found to show directed motion under UV-light illumination as well as to exhibit cargo capabilities, i.e. controlled pick-up, transport and release of individual and agglomerated particles [3]. Novel three-dimensional architectures consisting of gallium nitride microtubes with nanoscale wall thickness are demonstrated, their flexibility being investigated as a function of the technological conditions of sample preparation.

Efficient technological routes have been developed for the fabrication of highly flexible hybrid nanomaterials based on nano/micro-crystallites of wide-band-gap semiconductor compounds (GaN, ZnO) deposited on three-dimensional graphene aerogels and aerographite templates. It was found that the nano/micro-crystallites grow on the huge available surface and follow the network architecture of the porous template without agglomeration [4]. The dependence of doping upon growth direction was demonstrated by the growth of pencil-like gallium nitride nano/micro-crystallites exhibiting hexagonal shape and relatively sharp tip. Generation of various crystallographic planes during the growth of the tip made the incorporation of impurities site-dependent, resulting in a spatial distribution of luminescence colors along the tip [5].

Results of characterization of the morphology, chemical composition, crystalline quality, electronic and photonic properties of the developed flexible nanomaterials along with examples of their practical application will be presented.

[1] O. Volciuc, T. Braniste et al. *Proceedings of SPIE* **9519** (2015), 951904.

[2] M. Dragoman, I. Tiginyanu et al. *Nanotechnology* **27** (2016), 295204.

[3] M. Enachi, M. Giux et al. *Small* **12** (2016), accepted.

[4] A. Schuchardt, T. Braniste et al. *Scientific Reports* **5** (2015) 8839.

[5] I. Tiginyanu, M. A. Stevens-Kalceff et al. *ECS J. Solid State Sci. Technol.* **5** (2016) P218.