ELECTROCHEMICAL NANOSTRUCTURING

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The work represents a review of technological approaches for 2D and 3D nanostructuring of semiconductor compounds by using radiation treatment and electrochemistry. Novel spatial nanoarchitectures based on III-V and II-VI compounds as well as two-dimensional metallo-semiconductor structures are demonstrated. A breakthrough in the design and fabrication of ultrathin membranes of non-layered wide-band-gap semiconductor compounds is presented.

Over the last years, we elaborated technological approaches for 2D and quasi-3D nanostructuring of III-V and II-VI semiconductor compounds using anodic etching under controlled conditions. The nanostructured matrices served as conductive templates for the growth of arrays of metal nanotubes and nanowires by electroplating. As a result technological routes have been elaborated for the fabrication of two-dimensional metallo-semiconductor quasi-periodic structures for photonic applications. In particular, Platinum-semiconductor 2D quasi-periodic structures have been successfully elaborated on InP, GaP and ZnSe single crystalline substrates [1].

In our attempt to broaden the areas of applications of electrochemistry when combined with preliminary radiation treatment of samples, a few years ago we proposed the approach of surface charge lithography (SCL) as a tool for maskless microstructuring and nanostructuring of GaN epilayers. The approach is based on treatment of the semiconductor compound epilayer by a low-dose low-energy ion beam with subsequent photoelectrochemical (PEC) etching. The ion-beam induced lattice defects trap electrons leading to the appearance of a surplus of negative charge in the near-surface region of the GaN sample. The negative charge protects the ion-beam treated areas against PEC etching. Using the ion-beam-induced negative charge as a shield against PEC etching, we demonstrated unique possibilities for GaN nanostructuring, including fabrication of ultrathin GaN membranes suspended over networks of nanocolumns/nanowhiskers related to threading dislocations.

We found that photoelectrochemical etching of GaN combined with preliminary low-dose low-energy focused-ion-beam treatment of the sample surface provide conditions for both 2D and 3D micro-nanostructuring of this important electronic material. In case of 2D nanostructuring, it is possible to fabricate in a controlled fashion arrays of nanowires and nanowalls for sensor and photonic applications. By controlling the fluence of the ion treatment as a function of *x-y* coordinates, we reached conditions for the fabrication of both ultrathin membranes and supporting nanocolumns in the same technological route [2]. Note that PEC etching in-depth is possible due to high transparency of the membrane to ultraviolet light. Possible applications of the developed non-lithographic technologies and nanomaterials will be considered.

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[2] I.M. Tiginyanu, V. Popa, M. A. Stevens-Kalceff, D. Gerthsen, P. Brenner, and D. Pavlidis. *Phys. Stat. Sol. – Rapid Res. Lett.* **6** (2012) 148-150.