ELECTROCHEMISTRY-BASED MASKLESS NANOFABRICATION

Ion Tiginyanu*, Eduard Monaico, Veaceslav Popa****

*Laboratory of Nanotechnology, Institute of Electronic Engineering and Nanotechnologies, Academy of Sciences of Moldova, Chisinau 2028, Republic of Moldova

E-mail: tiginyanu@asm.md

**National Center for Materials Study and Testing, Technical University of Moldova, Chisinau 2004, Republic of Moldova

Abstract - A review of technological approaches for 2D and 3D nanostructuring of semiconductor compounds by using radiation treatment and electrochemical etching is presented. We demonstrate novel spatial nanoarchitectures based on III-V and II-VI compounds as well as two-dimensional metallo-dielectric structures realized in different geometries. It is shown that photoelectrochemical etching of GaN combined with preliminary low-dose low-energy focused-ion-beam treatment of the sample surface allows one to fabricate in a controlled fashion arrays of nanowires and nanowalls as well as ultrathin membranes and supporting nanocolumns in the same technological route. Possible electronic and photonic applications of the elaborated nanostructures are discussed.

Keywords: *Nanostructuring, etching, electroplating, nanowires, ultrathin membranes, semiconductors.*

1. INTRODUCTION

The technologies allowing one to manipulate with the spatial architecture of materials at the nanometer scale become more and more expensive when they are related to nano-lithographic top-down approaches or to precise handling with each atom or molecule used as building blocks in bottom-up approaches. Over the last decade, considerable research efforts were undertaken to develop cost-effective top-down and bottom-up nanotechnologies based on self-organization phenomena and self-assembling. In this review paper, we present new developments in top-down non-lithographic nanotechnologies based on electrochemical or photoelectrochemical (PEC) etching. We report, in particular, on maskless fabrication of cost-effective III-V and II-VI semiconductor nanotemplates, 2D quasi-periodic metallo-semiconductor structures and 3D spatial nanoarchitectures consisting of ultrathin membranes and supporting nanocolumns or nanowalls, the design of both membranes and nanocolumns/nanowalls being realized by focused ion beam (FIB) direct writing.

2. CONDUCTIVE NANOTEMPLATES

Two types of nanotemplates have been developed and widely used over the last decade for nanofabrication purposes, namely porous alumina (Al_2O_3) and etched ion track membranes based either on inorganic materials or on organic polymers [1-4]. These types of porous membranes, however, do not possess electrical conductivity and therefore they play only a passive role in nanofabrication processes. In this connection one of the goals of our efforts was to develop multifunctional semiconductor nanotemplates.

We found that anodic etching of single crystalline GaP, InP, ZnSe and CdSe in acidic solutions such as HCl, H_2SO_4, HNO_3 etc. leads to material porosification, although the porous architecture develops in different ways [5-9]. In GaP and InP compounds, porosification starts with the formation of crystallographically oriented pores in the so called nucleation layer. After multiple branching of the crystallographically oriented pores, anodic etching starts to produce current-line oriented pores exhibiting a pronounced tendency to form rows oriented along <110> direction. This tendency accompanied by the repulsive pore-pore interaction due to overlapping surface depletion layers surrounding neighboring pores leads to self-arrangement of pores and their ordered close packed 2D distribution.

No crystallographically oriented pores have been observed in II-VI compounds so far. After nucleation at the surface defects, the pores prove to be oriented along the current lines, exhibiting multiplication until the front of the porous network covers the whole available space [10, 11]. Along with the uniform porosification, in