Electrochemistry Communications 47 (2014) 29–32

Contents lists available at ScienceDirect

Electrochemistry Communications

journal homepage: www.elsevier.com/locate/elecom

Short communication

Formation of InP nanomembranes and nanowires under fast anodic etching of bulk substrates

Eduard Monaico [a,b], Ion Tiginyanu [b], Olesea Volciuc [c,*], Thorsten Mehrtens [c], Andreas Rosenauer [c], Jürgen Gutowski [c], Kornelius Nielsch [a]

[a] Institute of Applied Physics, University of Hamburg, 20355 Hamburg, Germany
[b] National Center for Materials Study and Testing, Technical University of Moldova, 2004 Chisinau, Republic of Moldova
[c] Institute of Solid State Physics, University of Bremen, 28334 Bremen, Germany

ARTICLE INFO

Article history:
Received 7 July 2014
Received in revised form 21 July 2014
Accepted 21 July 2014
Available online 31 July 2014

Keywords:
Anodic etching
Nanomembrane
Nanowire
Porous InP

ABSTRACT

We demonstrate that fast anodic etching of bulk crystalline substrates of *n*-InP via photolithographically defined windows leads to the formation of nanomembranes and nanowires being promising for device applications. It is shown that, under potentiostatic etching conditions, the morphology of etched samples strongly depends on the applied voltage. We found that anodization at 5–7 V results in the formation of highly porous layers with mechanically stable skeletons exhibiting percolation, which easily detach from the substrate thus representing nanomembranes. At the same time the predominant formation of nanowires was evidenced at further increase of the applied voltage up to 15 V. Uniform deposition of Au dots on InP nanowires and nanowalls is demonstrated using electroplating.

1. Introduction

In the last decade, considerable research efforts have been focused at the scientific exploration of one-dimensional (1D) and two-dimensional (2D) nanostructures such as nanorods, nanowires, nanotubes, nanobelts, and nanomembranes. Due to the quantum size effects and large surface-to-volume ratios, 1D and 2D nanostructures exhibit fascinating properties resulting in novel nanooptoelectronic and nanosensor device applications. Note that semiconductor nanowires are predicted to drive new generations of compact, ultrafast, and high efficiency electronic and optoelectronic devices. III–V semiconductor nanowires, in particular, show enormous potential for their use as active components in solar cells [1–4], photodetectors [5], light-emitting diodes [6], and ultrahigh-density transistors [7]. At the same time, 2D nanomaterials, including continuous and perforated nanomembranes, have proven to be advantageous for charge transport and surface-enhanced interactions/reactions, feasible for applications in electrodes of dye-sensitized solar cells [8–10], gas sensors [11,12], supercapacitors, photocatalytic water splitting, photocatalysis [13] etc.

Among the III–V materials, InP is of special interest for making nanostructures due to its direct band gap of 1.34 eV thus absorbing light over a broad range of solar spectrum wavelengths. Besides that, InP possesses a high electron mobility and is a rather mature material from the point of view of electrochemical processing. Formation of single crystals of nanopores in *n*-type InP is possible via self-organized electrochemical etching processes [14,15]. Along with this, anodic etching via photolithographically defined windows produces ordered geometric patterns consisting of InP nanoporous structures promising for photonic applications [16], while periodic modulation of anodizing current or the applied potential with time leads to the formation of porous superlattices consisting of a stack of two layers with alternating high and low porosity [17,18].

In this paper, we report on the possibility of cost-effective fabrication of InP nanomembranes and nanowires using fast anodic etching of *n*-InP single crystalline substrates under potentiostatic conditions. Fast anodic etching means that 2-μm long nanowires are obtained in just 3 s of anodization, i.e., the rate of etching in depth direction is about 40 μm/min. Uniform electrochemical deposition of Au dots on InP nanomembranes and nanowires is demonstrated.

2. Experimental data

Crystalline (100)-oriented substrates of sulfur doped *n*-InP with 500 μm thickness and a free electron concentration of $1.3 * 10^{18}$ cm^{-3} were supplied by CrysTec GmbH, Germany. Before the anodization process, conventional photolithography was used to open windows in the photoresist covering the top surface of the samples. Anodic etching was applied to these samples through opened rectangular windows with a breadth of 35 μm. An electrical contact was made on the backside of the anodized samples with a silver paint. The anodization of the InP

* Corresponding author at: Institute of Solid State Physics, University of Bremen, Otto-Hahn-Allee 1, 28359 Bremen, Germany. Tel.: +49 42121862205 (phone); fax: +49 42121862251.
E-mail addresses: volciuc@ifp.uni-bremen.de, olesea.volciuc@gmail.com (O. Volciuc).

http://dx.doi.org/10.1016/j.elecom.2014.07.015
1388-2481/