ONE DIMENSIONAL NANOMATERIALS SYNTHESIZED USING HYDRAZINE VAPOR

Jishiashvili D., Shiolashvili Z., Makhatadze N., Kiria L.

V. Chavchanidze Institute of Cybernetics. Georgian Technical University
5, Euli Str. 0186 Tbilisi, Georgia
e-mail: d_jishiashvili@gtu.ge

One dimensional nanomaterials (nanotubes, nanowires, nanofibers, nanobelts etc.) are considered as the main building blocks of modern nanodevices which can serve as transient materials for the future quantum dot based advanced nanocircuits and devices. Except laser ablation, the synthetic methods for producing one dimensional ($1D$) oxides, nitrides, phosphides usually rely on the use of corresponding vapor flows and in most cases need relatively high temperatures exceeding $\sim 600^0C$.

The purpose of this work was to develop a hydrazine-based simple and efficient new technology for fabricating new $1D$ nanomaterials (nitrides, oxynitrides, oxides, phosphides) of Ge, In, Ga and Ge-In, Ge-Zn, In-Ga, In-Zn, In-Ga-Zn systems. Another purpose was to investigate the properties of the emerging novel nanomaterials in order to evaluate their application potential in different nanodevices.

The composition and structure of $1D$ nanomaterials were analyzed by X-ray diffraction, Energy Dispersive Spectroscopy, Transmission and Raster Electron Microscopy.

The hydrazine (N_2H_4) vapor was chosen as a chemically active ambient due to its low pyrolysis temperature and ability to form active radicals and reducing agents like hydrogen. For producing oxide and oxinitride nanowires (NWs) the hydrazine was diluted with water (up to 3 mol.%). 1D nanomaterials were grown in the vertical quartz reactor. The solid source materials were placed on its heated bottom. After evaporation of sources and chemical reactions the NWs were growing on the substrates located at some distance above the source. In contrast to traditional growth methods with dynamic gas flows, the static pressure of hydrazine ($\sim$ 10 Torr) was preserved during the whole nanowire growth time (0.5 - 5.0 hours).

Using this technology following $1D$ nanomaterials were synthesized: Ge_3N_4, $In_2Ge_2O_7$, InN, InP, InP:Zn, $In_xGa_{1-x}P$. The initial experiments clearly show that during the NW growth processes the hydrazine vapor can serve a variety of purposes.

Due to high activity of hydrazine vapor the growth temperature of Ge_3N_4 nanowires and nanobelts were decreased by 300^0C in comparison with data presented in literature. When growing the phosphide NWs at low temperatures ($\sim 500^0$C), the nitriding ability of hydrazine was diminished, however its reducing effect served to prevent the oxide formation and the stoichiometric InP, InP:Zn and $In_xGa_{1-x}P$ were produced. The mixture of $In_2Ge_2O_7$ and InN nanowires were formed when the In-Ge was used as a source material. The minimum diameter of 6 nm was reached in InP nanowires and the minimum thickness of two molecularar layers was obtained for Ge_3N_4 nanobelts.

The NWs were growing by different mechanisms depending on the source material and substrate temperature. These mechanisms include the catalyst and self-catalyst assisted Vapor-Liquid-Solid methods, Oxide Assisted Growth through the Vapor-Solid mechanism and the sidewall deposition processes.

The results of this work demonstrate the potential of the hydrazine-based technology and prove the applicability of this technology for the low temperature synthesis of different 1D nanostructures.