Nanostructure Synthesis and Fabrication
Room On Demand - Session NS6

Nanostructures Synthesis and Fabrication Poster Session

NS6-1 Synthesis of Silicon Carbide Thin Films by Post-Processing of Molecular Layer Deposition (Mld) Polyamide Films on Silicon*, **Rustam Amashaev**,* Dagestan State University, Russian Federation*; I. Abdulagatov,* Dagestan State University , Russian Federation

Silicon carbide (SiC) is a technologically important material that has many industrial applications. SiC films on Si substrates have been used to fabricate transistors, optical waveguides and components for quantum computers. In addition, SiC films have been used to obtain another technologically significant material – graphene. There are several primary ways to deposit SiC films: physical and chemical vapor deposition (PVD and CVD). Although these methods can deposit good quality films, they cannot fulfill all the stringent requirements, in terms of film conformality, thickness control, and cost effectiveness, needed to manufacture modern microelectronics devises.

In this work, we studied alternative approach for controlled synthesis of epitaxial quality SiC thin film. This method based on pyrolysis of MLD polyamide film deposited on single crystal Si substrate (see Fig.) [1]. MLD allows to deposit highly conformal organic thin film with precise thickness control. Consequently, it might be possible by controlling the parameters of the initial MLD film accurately control the thickness and uniformity of the SiC film.

MLD polyamide films were deposited at 120 ^{o}C by thermally stimulated surface reactions between trimesoyl chloride (TMC) and 1,2-ethylenediamine (EDA). *In situ* QCM monitoring of the MLD process showed linear increase in mass with the number of cycles. The polyamide film growth rate on Si(111) was 18.5 Å/cycle. After deposition, pyrolysis was conducted at temperatures between 1000 and 1300 ^{o}C and pressure of ~10^{-7} Torr. Number of *ex situ* characterization methods, such as, scanning electron microscopy (SEM), x-ray diffraction (XRD), Raman, energy-dispersive x-ray spectroscopy (EDX), and reflection high-energy electron diffraction (RHEED) were employed to analyze samples after pyrolysis. These techniques confirmed that after heat treatment single crystal b-SiC (3C-SiC) thin films have been synthesized.

[1] Amashaev, R et. al. Molecular Layer Deposition and Pyrolysis of Polyamide Thin Films on Si(111) with 3C-SiC film formation, *Russ. J. Phys. Chem.* Accepted; Patent application: RU2020133824A.

NS6-2 Fabrication of Free-standing Three-dimensional Structures by Spatial Atomic Layer Printing*, **Philipp Wiesner**, I. Kundrata,* ATLANT, Germany*; S. Tymek, M. Barr,* Friedrich-Alexander-University Erlangen-Nürnberg (FAU), Germany*; M. Plakhotnyuk,* ATLANT, Denmark*; J. Bachmann,* Friedrich-Alexander-University Erlangen-Nürnberg (FAU), Germany

One of the most common processes to produce microelectronics is optical lithography. It combines deposition by different thin film techniques including CVD or ALD with etching of defined structures using masks.This multistep procedure is time-consuming and wasteful of material. Spatial Atomic Layer Printing offers an alternative for the direct production of defined structures and therefore for components in microelectronics.

In this study, free-standing three-dimensional bridges are produced using the atomic layer 3D printer, developed by ATLANT 3D Nanosystems, that provides direct atomic layer writing process. For this purpose, two crossing lines are deposited from a support and a print material, subsequently the support material is removed via wet chemistry etching processes. To ensure an intact bridge, different material combinations of platinum, titanium dioxide, silicon dioxide and zinc oxide are used and post-processed by different etching methods. In particular, the materials used and the type of etching play an important role in producing freely standing structures. Important aspects in the preparation of the component are the influence of the etchant on the materials, the temperature used, the surface tensions of the etchant and the cleaning agent as well as the mechanical stress during the process.

The most promising material combination during the test series is a printing material of titanium dioxide deposited with TTIP and H2O and a support material of zinc oxide deposited with diethylzinc and H2O. To ensure the gentlest possible etching process, the support material is removed by vapor etching using hydrochloric acid and the sample is cleaned by immersion in a mixture of 90 % ethanol and 10 % water. As a result, most of the titanium dioxide bridges are retained and can be characterized (see Figure 1). The samples produced still have cracks and spalling on the bridges, but it can be demonstrated that the ATLANT 3D Nanosystems atomic layer 3D printing process can be used for the direct deposition of free-standing three-dimensional structures that can be further used to fabricate components in microelectronics.

NS6-5 Al_2O_3 ALD Buffer Layers for Epitaxial Growth of Boron Nitride Beyond the Self-Termination Limit*, **Mateusz Wlazło**,* CBRTP - Research and Development Center of Technology for Industry, Poland*; P. Caban,* Łukasiewicz Research Network - Institute of Microelectronics and Photonics, Poland*; G. Kołodziej ,* CBRTP - Research and Development Center of Technology for Industry, Poland*; P. Michałowski ,* Łukasiewicz Research Network - Institute of Microelectronics and Photonics, Poland

The Metalorganic Chemical Vapor Deposition (MOCVD) is a recognized method for the growth of BN epitaxial layers. The important progress in the understanding of the MOCVD growth was achieved when it was demonstrated that the growth mode could be changed from 3D to self-terminated one under high reactor pressure and increased in V/III ratio. It is known that the main problem in the deposition of BN layers is that in self-terminated mode the total layer thickness does not exceed 2nm.In this presentation structural properties of BN layers grown directly on the Al2O3, or using Al2O3 buffer layers made by ALD were investigated. Application of one or two buffer layers was investigated as well as Al2O3 buffer properties. The measurements techniques used for investigation of the grown films concentrated on AFM however involved SIMS, ATR spectroscopy, XRR, Raman. The motivation behind this work is to show directions towards the increase of the total layer thickness.

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