GROWTH OF MWCNTS ON SAPPHIRE SUBSTRATE AS AN INTERMEDIATE LAYER FOR III-V GROUP STRUCTURES

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The main purpose of this paper was using of CNTs as an intermediate layer between sapphire substrate and GaN structures. Therefore, the MWCNTs were deposited on the sapphire substrate with the synthesis of carbon nanotubes done by the aerosol-CVD method. The optimal growth regime was determined from the characterization of CNTs by Raman, SEM and TEM investigations. The investigations showed that the MWCNTs were grown on the substrate horizontally. The inside of tubes was predominantly empty with some of them containing Fe in the tip or on some parts of the walls. The external diameters of the MWCNTs were 25-35 nm.

Keywords: MWCNTs, sapphire, Aerosol-CVD.
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INTRODUCTION

Applications based on wide bandgap III-V compound semiconductors have rapidly developed over the last several decades due to the ability to apply these semiconductors in high-power, high-frequency electronic and optoelectronic devices [1-4]. Nowadays, biosensors are becoming most important due to their applications in biological and chemical analyses, biomedical, diagnostics, clinical detection, food safety industry, and environmental monitoring. In recent years III-nitride semiconductors have also attracted interest from the scientific community for other applications such as gas and biosensors. Due to their inherent material properties, such as their thermal and chemical stability and biocompatibility, group III-nitrides are a promising material system for the realization of sensitive and stable transducers for biosensor devices. GaN based sensors have been started to study over the last decade (Luther et al., 1999 and Schalwig et al., 2002) and has been studied more and more in recent years [5, 6]. These diverse types of biosensors have been actively pursued by many researchers, using thermometric, piezoelectric, magnetic, and optical transducer approaches [7- 9]. The GaN based optical biosensors are regarded as a promising future real-time biomedical sensor due to the advantages of low temperature drift, low power consumption, low cost, visible radiation application, nondestructive operation, and fast signal generation and reading. Optical biosensors using light absorption of biological elements and photodiode detection have been reported in several studies. Additionally, chemical and other various types of GaN-based (bio)sensors have been started to be investigated during the last decade [10, 11]. The material is chemically stable and inert and, has good optoelectronic properties. GaN also has a large bandgap, therefore the highest occupied and lowest unoccupied orbitals of many biomolecules match very well with it. Taking into consideration all these studies up to now, we can say that III-N materials have a great opportunity to fabricate various types of next generation biosensors. The realization and application of GaInN quantum well heterojunctions as optical transducer elements in chemical sensing and bio-sensing has begun to be demonstrated by many groups since last few years [12-15]. However, large differences in fundamental properties such as lattice constants and thermal expansion coefficients between GaN layer and sapphire substrate generate structural defects and high density of threading dislocations (TD) that leads to deterioration of optical and structural properties.

Carbon nanotubes (CNTs) are innovative nanomaterials due to their high mechanical, thermal and electronic properties (mechanical flexibility, extremely high intrinsic mobility, high thermal conductivity, high elasticity and high optical transmittance) [16-17]. Recently, research groups have been analyzing CNTs to improve the crystal quality of GaN by applying CNT as an intermediate layer between sapphire substrate and GaN buffer layers. Therefore high thermal conductivity, high elasticity and high optical transmittance properties of CNTs make them ideal for electronics devices. In this work, we mainly analyses the impact of CNTs to improve the crystal quality of the GaN structures.

EXPERIMENT

The synthesis processes were carried out by conventional aerosol-chemical vapor deposition (A-CVD) (Fig. 1a) technique (SCIDRE, Germany) which the organic hydrocarbon solvents are used as carbon source. The investigations of MWCNTs/sapphire sample which is grown at optimal growth condition was describe in this paper. This work is based on the injection of the cyclohexane solution in the reactor as an aerosol and its decomposition under high temperature (850ºC). The high frequency (7800 kHz) has been fed in by an ultrasonic device (transducer) to obtain an aerosol from the cyclohexane solutions. Ar/H_2 mixture has flowed to the system during the synthesis process as a transport gas with a total flow ratio 11:1 (constant total flow rate of Argon (Ar) 1100 ml/min and the hydrogen (H_2) 100 ml/min. Argon is the main carrier gas, introduced into the growth chamber. Hydrogen H_2 plays an important role since it controls the growth rate. H_2 was known to have the ability to either accelerate or suppress the formation of carbon.

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In general, the process starts by putting Fe covered sapphire substrate in to reactor and the evacuation of the air from quartz reactor using Ar flow for 30 min followed by heating the reactor to 850 °C. Then the aerosol was created from the solution by ultrasonic device with 800 kHz high frequency and was carried by gases to the reactor for CNTs growth. The syntheses proses were continued during 10 minutes and after the synthesis, the reactor always is cooled down under Ar flow. Firstly, the G, D and 2D peaks of the sample was investigated by Raman (Fig. 1b).

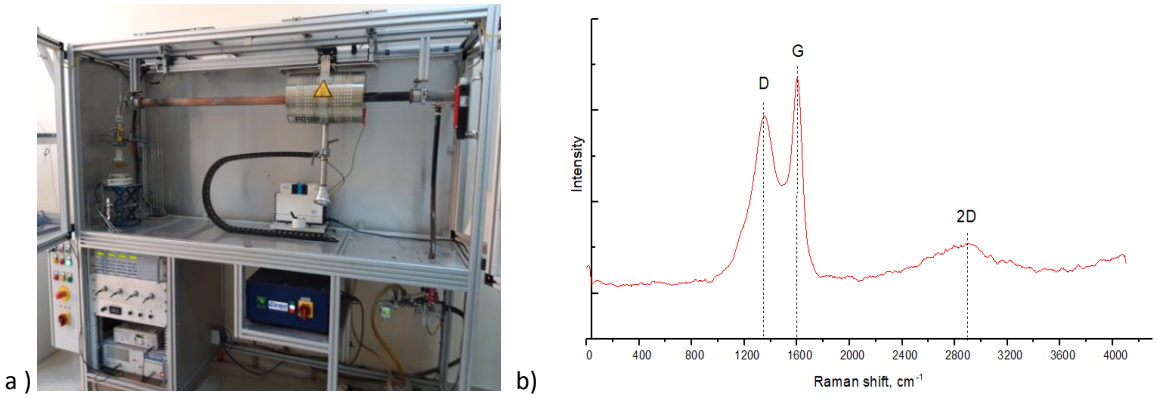


Fig. 1. A-CVD system and Raman characterization of MWCNTs.

RESULTS AND DISCUSSION

The growth of MWCNTs on sapphire mainly studied by scanning electron microscope (SEM) (Fig. 2) and transmission electron microscope (TEM) (Fig. 3). The tubes consist of approximately 25-35 nm diameters. Figure 3 gives the Tem images and present (%) concentrations of only C, O, and Fe as if silicon were absent. Carbon is due to the fact that C surrounds the nano particles so that the TEM electron beam passes through the C shell as well, which generates the C peak in the EDS spectra. The same applies for oxygen. The C signal/percentage can also be due to the presence of CFe3 in the nano particles.

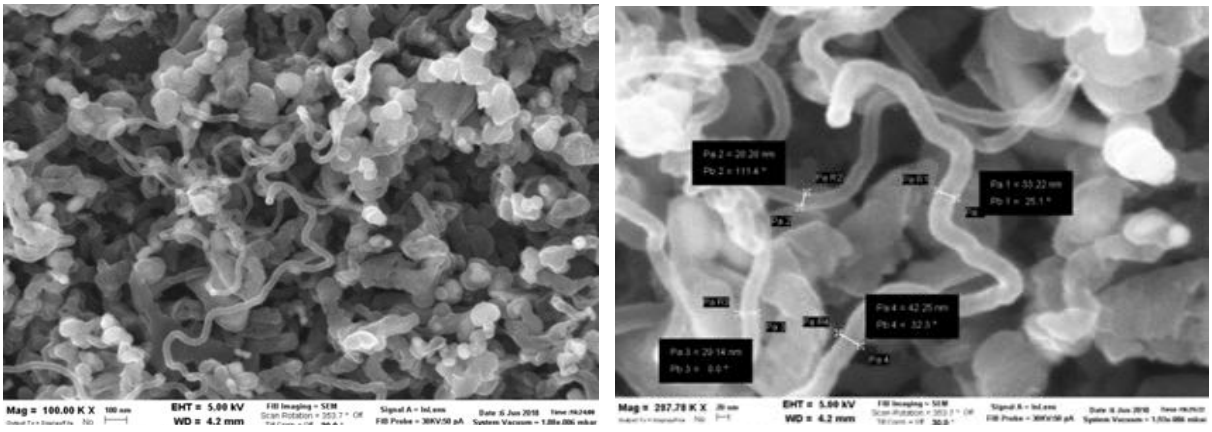
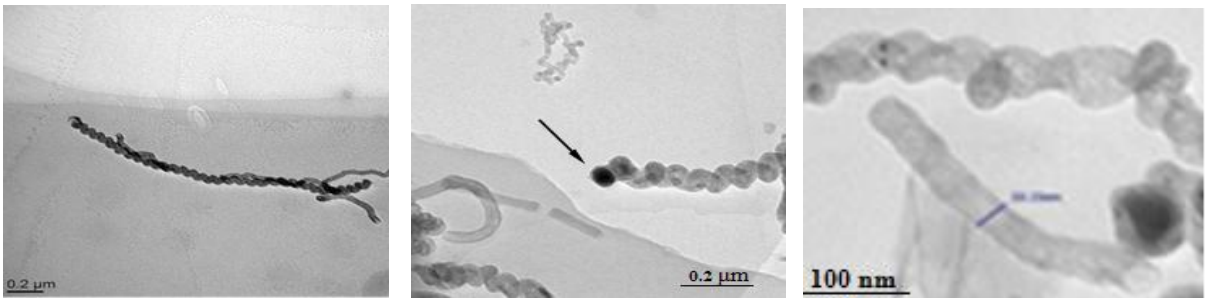


Fig. 2. SEM images of MWCNTs



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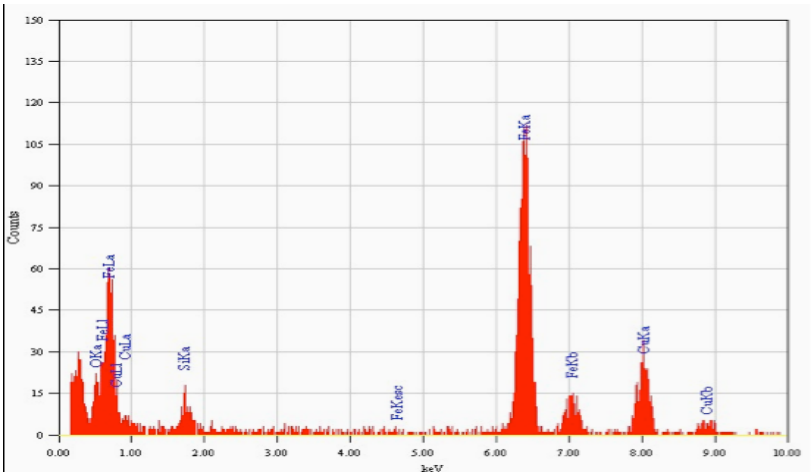

Fig. 3. TEM images and EDS spectra of MWCNTs

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