GROWTH OF GALLIUM NITRIDE NANOWIRES BY LOW PRESSURE CHEMICAL VAPOR DEPOSITION (LPCVD)

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This thesis submitted to the Nanyang Technological University in fulfillment of the requirement for the degree of Master of Engineering

2012
STATEMENT OF ORIGINALITY

I hereby certify that the work embodies in this thesis is the result of original research and has not been submitted for a higher degree to any other University or Institution.

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ABSTRACT

Group-III nitrides such as gallium nitride (GaN) have been intensively used for high power electronic, optoelectronic, RF power and sensor applications such as blue light emitting diodes (LEDs), high power and high voltage transistors, etc. In recent years, nanowires have gained interest due to the ability to take advantage of their geometry for improving optical and electrical properties such as increased light absorption, and the freedom synthesis of high quality nano heterostructures on different substrates with large lattice mismatching. Growth of III-Nitride nanowires on Si, which is the most commonly used substrate in microelectronic industry, using different growth techniques such as conventional Chemical Vapor Deposition (CVD), Metal Organic Chemical Vapor Deposition (MOCVD), and Molecular Beam Epitaxy (MBE) etc. have been explored. Low pressure chemical vapor deposition (LPCVD), which is widely used in Si wafer fabs, is of particular interest due to its low cost, ability to handle large size wafer and high throughput. However, the reports on GaN nanowire growth using LPCVD are very limited. It is of technical interest to perform a systematic study to determine a growth window for GaN nanowires using LPCVD, and explore their properties.

In this master degree thesis, the growth of GaN nanowires on Si using a LPCVD is reported. Preliminary studies on the effect of growth conditions on GaN nanowire formation in a LPCVD system were carried out. The impact of growth conditions such as temperature, pressure, substrate orientation on the formation of GaN nanowires was investigated. The results demonstrate a strong dependence of GaN nanowire growth and its morphology on the growth temperature. It was observed that the GaN nanowire morphology and density could also be
affected by the pressure during the growth. Furthermore, the use of different metals (Au and Ni) as the catalyst for the growth was also explored. Ni-catalyzed GaN nanowires with high GaN nanowire density were found to occur at an optimal growth temperature around 750 °C, which is significantly lower than the typical GaN nanowire growth temperatures using thermal CVD in the literatures. SEM observations show that GaN nanowires exhibit a slightly tapered shape. An average diameter around 17 nm was achieved using 3 nm Ni catalysts grown at a temperature of 700 °C. The GaN nanowire properties were further studied by using XRD, PL and Raman spectroscopy. The XRD and Raman measurements suggest that the GaN nanowires grown by LPCVD are predominated by hexagonal GaN phase with the wurtzite structure. Photoluminescence spectra at room temperature revealed a sharp emission peak at 359 nm. A full width at half maximum (FWHM) of 101 meV was obtained. The experimental results suggest that the formation of high density GaN nanowires can be realized by using LPCVD technique with a reasonable process window. The GaN nanowires can be potentially used for optoelectronic and electronic applications.
ACKNOWLEDGEMENTS

Firstly, I would like to express my heartfelt thanks to my supervisor, Associate Professor Wang Hong, for his excellent guidance and his opportunities given to me. During the exploration of this research project, Associate Professor Wang has provided significant amount of materials and resource for experiment towards the research. I am able to embark on the project, largely due to his opportunity given. I am also very grateful for the patience that he has shown towards me when I conducted experiment.

Secondly, I would like to thank Assistant Professor Cesare Soci for his advice on the theoretical knowledge towards the topic. My thanks also go to my research teammate: Ms. Agnès Messanvi for her great help at the late stage of the experiment. Dr. Zhang Sen has helped in providing SEM training for me and Mr. Mak Foo Wah for the LPCVD training. My appreciation goes out to people who had helped me especially my family and friends who gave me courage when I started the graduate program after return from the industry in Europe.

Finally, I would like to thank School of Electrical and Electronics of Nanyang Technological University, Singapore as well as the CINTRA CNRS/NTU/THALES for giving me the chance to embark on this research project.