Optik 127 (2016) 4396–4399

Contents lists available at ScienceDirect

Optik

journal homepage: www.elsevier.de/ijleo

Short note

Comparative optical spectroscopy of gallium-nitride and aluminum-nitride nanostructures deposited onto silicon substrate

Mufei Xiao *

Centro de Nanociencias y Nanotecnología, Universidad Nacional Autónoma de México, km. 107 Carretera Tijuana-Ensenada, Ensenada CP 22860, Baja California, Mexico

ARTICLE INFO

Article history:
Received 8 December 2015
Accepted 18 January 2016

Keywords:
Gallium-nitride nanowire
Aluminum-nitride thin film
Optical spectroscopy

ABSTRACT

In the present work, a comparative study of optical spectroscopy of two kinds of samples, namely, gallium-nitride nanowires grown on silicon surface and aluminum-nitride thin film deposited also on silicon substrate has been carried out. The purpose of the study is to explain as much as possible the spectrums in relation with the surface details. It is shown that optical reflection spectroscopy in the visible would be a simple, fast and non-destructive tool for evaluating the nanostructures.

1. Backgrounds

Recently, there has been increasing interests in creating nanostructures on dielectric surfaces, so that optical transmission/reflection via the surface can be modulated by the nanostructures, which provides chances for various photonic applications. Among others, growing gallium-nitride (GaN) nanowires and nanodots on dielectric substrates appears attractive [1–3]. As an III–V nitride semiconductor, GaN are especially suitable for constructing compact optoelectronic devices, such as laser diodes and blue LED, thanks for its wide gap between the conduction and valence bands (∼3.4 eV) and relatively high electric and thermal conductivities. GaN nanorods and nanodots further limit the movement of the carriers, i.e. the carriers are quantum mechanically confined. Depending on the degree of the quantum confinement, more photonic features become possible, which opens novel opportunities for more device functionalities in various photonic and optoelectronic applications.

One of the methods to create GaN nanostructures on silicon wafers is to use gold as the catalyst after a process of chemical vapor deposition. The samples are heated to a certain temperature, GaN nanowires are formed with gold particles sitting on top of the wires. However, it has been found that the status of the fabricated nanorods varies significantly even for the same deposition and heating conditions. When a sample is processed under certain deposition conditions, it is difficult to have a sample surface with a satisfactory uniformity. It means that on the same surface and with the same deposition conditions, the nanorods at different positions could be significantly different. Therefore, it becomes highly desired to have a nondestructive testing tool to evaluate the surface and especially to check out the uniformity of the sample.

Apart from GaN nanostructures, we have also been studying on other nitride related III-V semiconductors, for example, aluminium-nitride (AlN) thin films. AlN thin films were used to devise light-emitting diodes (LEDs) with wavelengths as short as 210 nm [4]. The ultraviolet emission was realized thanks for the wide direct bandgap of AlN (>6.2 eV) [5,6] and the findings that conductivity of AlN could be controlled by both p- and n-type of doping [4]. Apart from photonic applications, AlN is usually known as a material of high hardness, high thermal conductivity, and high resistance to temperature and caustic chemicals. Therefore AlN thin films have been widely employed for electronic packing [4].

AlN thin films can be deposited with a variety of techniques. In past times, pulsed laser deposition (PLD) becomes attractive for several reasons. The technique is inexpensive and requires relatively low growth temperature. Recently, PLD deposition of AlN thin films was widely employed [7]. It was found that AlN films deposited with PLD could behave either dielectrically or metallically as far as its optical properties are concerned and the phase transit depended closely on the pressure of the nitrogen gas during the deposition. A number of testing tools were used to study the microstructures of the AlN thin films, such as Auger electron spectroscopy (AES), X-ray photoelectron spectroscopy (XPS), atomic force microscopy (AFM), scanning electron microscopy (SEM), and profilometry etc. However, it is also desirable to have a simpler tool

* Corresponding author. Tel.: +52 646 175 6050.
E-mail address: mufei@cnyn.unam.mx

http://dx.doi.org/10.1016/j.ijleo.2016.01.141
0030-4026/

for the characterization, such as optical microscopy. The testing has also to be nondestructive and easy to be implemented [8].

2. Optical spectroscopy in the visible

Therefore, one comes to an understanding that there is a need to have a handy tool to test surfaces, and the testing has to be nondestructive and easy to implement. Optical spectroscopy in the visible would be a favorable selection, especially optical reflection spectroscopy. Of course, one does not expect to replace other surface tools, such as SEM photos. However, since there is no need to prepare the sample surface for the test, optical reflection spectroscopy would be used for a first stage testing before any further testing with more sophisticated instruments.

In the present work, we have carried out optical reflection spectroscopy in the visible over the aforementioned two kinds of samples, namely, GaN nanowires grown on silicon surface and AlN thin films deposited also on silicon substrate. Both samples are of nitride related composites, but with completely different nanostructures on the surface. The purpose of our study is to see how much one is able to learn from the obtained optical spectrums.

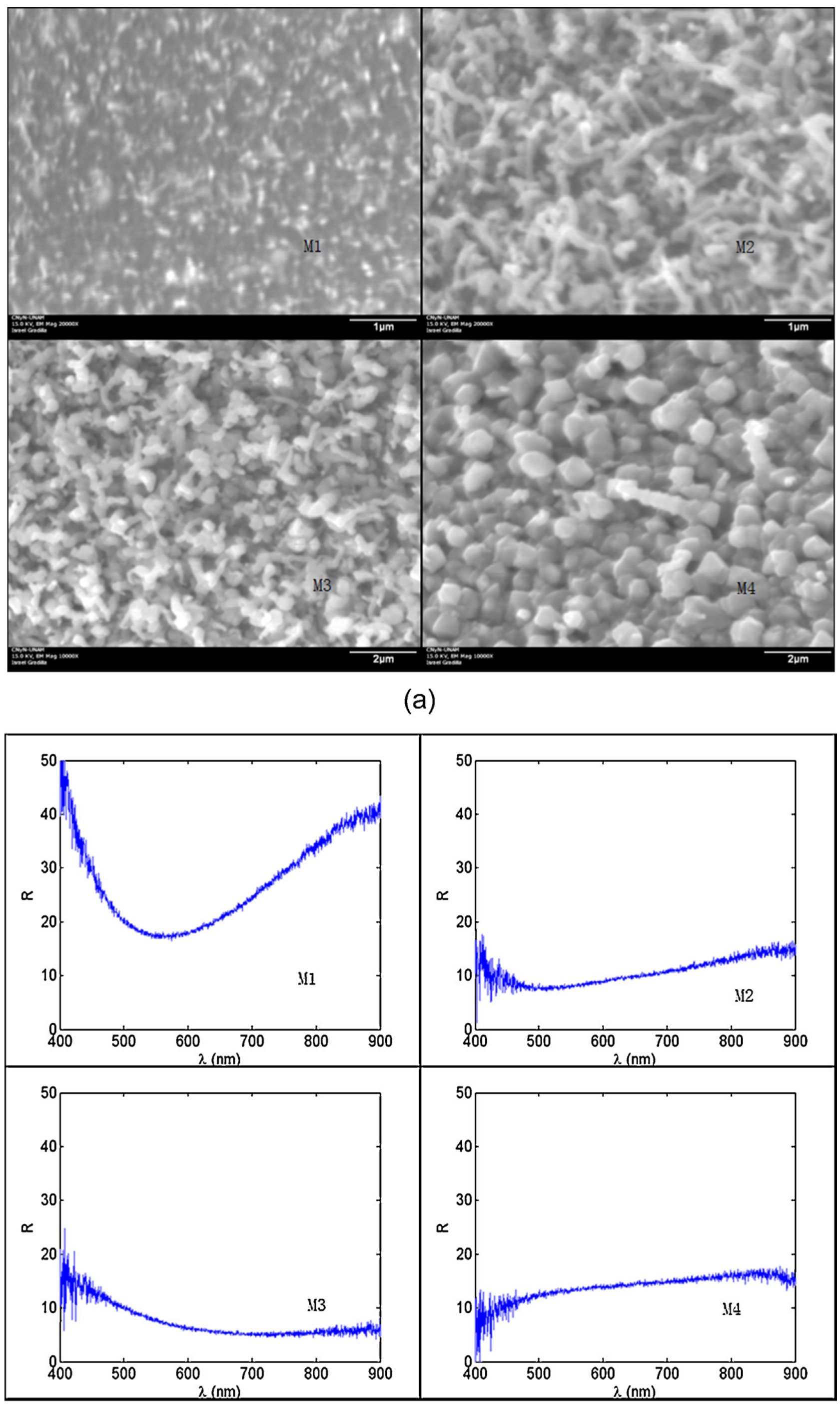

Fig. 1. SEM images (a) and the corresponding optical refection spectrums (b) for four samples (M1, M2, M3, and M4) of GaN nanowires on Si substrate.