Influence of hexagonal-shaped surface pits on optical and structural properties of GaN epilayers grown on Al_2O_3 substrates by MOCVD

A. Guillén-Cervantes[1*], Z. Rivera-Álvarez[1], M.A. Aguilar-Frutis[2], C. Falcony-Guajardo[1], M. López-López[1], V. M. Sánchez-Reséndiz[3].

[1] *Physics Department, CINVESTAV-IPN, Av. IPN 2508, Zacatenco,07360 México, D.F.*
[2]*Centro de Investigación en Ciencia Aplicada y Tecnología Avanzada del IPN Legaria 694, Col. Irrigación 11500 México, D.F.*
[3] *Electrical Engineering Department, Solid State Section, CINVESTAV-IPN, Av. IPN 2508, Zacatenco, 07360 México, D.F.*

Abstract
GaN films grown on (0001) sapphire substrates in a low pressure MOCVD quartz reactor at low temperature (~900 º C), were characterized by atomic force microscopy, secondary electron microscopy, micro-Raman, X-ray diffraction, and ellipsometry both spectral and at fixed wavelength.

Introduction
In recent years, the GaN semiconductor and its III-V alloys have been considered promising materials for applications in optoelectronics and high power electronic devices due to their unique properties like a wide direct bandgap capable of covering, for the case of photonic devices, from the visible to the ultra-violet region of the electromagnetic spectrum. As a matter of fact, short-wavelength light emitting diodes and lasers have been developed at commercial scale (1-5). In spite the extensive research devoted to the III-V nitrates, many problems concerning structural and crystalline aspects must be solved. In this work we realized a study of GaN films grown by low pressure MOCVD. Hexagonal-shaped pits were observed on the GaN surface, we discuss their origin and influence on the optical and structural properties of the samples.

Experiment
The GaN epilayers were grown on the (0001) c-plane of Al_2O_3 substrates at different reactor pressure. The MOCVD system consists of a home-made quartz chamber with a graphite susceptor coated with SiC. Trimethylgallium (TMGa) and ammonia (NH_3) were used as precursors and high purity hydrogen (H_2), from a palladium membrane filter, as the carrier gas.

Results
A SEM micrograph of sample M435 is shown in the figure 1a. In the image dark zones with hexagonal shape and clear extended regions are observed. These later regions correspond to the GaN film while the darker zones are hexagonal-shaped surface pits. The sample was grown with a reactor pressure of 95 Torr. Hexagonal pits on the GaN surface have a density around 5 X 10^7/cm^2. Pits can be as large as 1 μm from opposite sides, the fixed wavelength ellipsometry analysis estimated the film thickness in 1.57 μm and the refraction index in 1.9.

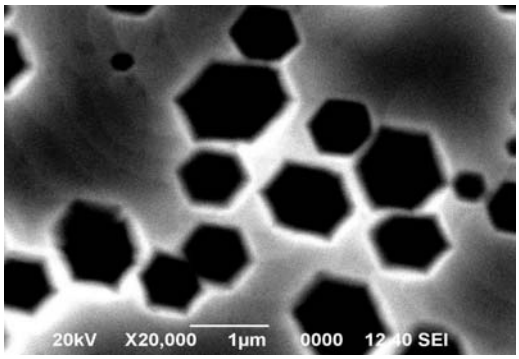

Fig 1. A SEM micrograph of hexagonal-shaped pits on the GaN surface.

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References
[1] Shuji Nakamura, Masayuki Senoh, Naruhito Iwasa and Shin-ichi Nagahama, Jpn. J. Appl. Phys. 34 (1995) L797.
[2] Shuji Nakamura, Masayuki Senoh, Shin-ichi Nagahama, Naruhito Iwasa, Takao Yamada, Toshio Matsushita, Hiroyuki Kiyoku and Yasunobu Sugimoto, Jpn. J. Appl. Phys. 35 (1996) L74
[3] Akasaki, S. Sota, H. Sakai, T. Tanaka, M. Koike and H. Amano, Elect. Lett. 32 (1996) 1105.
[4] T. Nishida, T. Ban and N. Kobayashi, Phys. Stat. Sol. 200 (2003) 106.
[5] D. Jin, R. Connally and J. Piper, J. Phys. D. Appl. Phys. 39 (2006) 461.