GaNeX

2017-THESE

- Axe de GANEX : 7
- Titre du sujet : **Atomic scale studies of high O and Si doping effects on III-N films properties**
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- Nature de la thèse
   Partagée internationale : (financement 50% GANEX/ 50% étranger)
  laboratoire bénéficiaire et partenaire étranger: CRHEA /IKZ Berlin
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- Sujet développé:

High doping of III-N films with chemical elements like O and Si offers new perspectives for controlling either their growth or properties. The purpose of this PHD is to study the effects of such high doping levels on the structure of III-N at atomic scale.

III-N crystallize in the wurztite polar structure. The control of the polarity of these films remains challenging. If the growth of metal-polar (Me-polar) 2D-films is nowadays well controlled, the situation is less clear for N-polar 2D films or for nanowires. The results of the previous GANEX PHD shared between CRHEA and IKZ (N. Stolyarchuk) have shown the importance of the presence of an oxynitride formed by the nitridation of the sapphire substrate in the selection of the polarity of the films[i]. The presence of an unintentionally introduced O-rich monolayer allows the switching of the polarity from N-polar in the first few monolayers to Me-polar. The first goal of this PHD will be to play with the intentional O incorporation in order to control the switching of polarity from N-polar to Me-Polar or from Me-polar to N-polar, in both AlN and GaN. Such a control would allow obtaining pure N-polar 2D films but also the fabrication of heteropolar structures with lateral or vertical alternating polarities. These heteropolar structures open the way for new devices concepts either for microelectronic or non-linear optics.

The well-known “SiN” treatment of surfaces has several effects of major importance in the III-N growth:

- The control of the growth morphology (2D versus 3D) which allow a drastic reduction of the dislocation densities
- The fabrication of top-down nanowires
- The passivation of AlGaN/GaN high electron mobility transistors

The crystalline structure of the $GaSiN_3$ monolayer formed by the SiN treatment during metalorganic vapor phase epitaxy (MOCVD) growth of GaN has already been resolved[ii]. The second goal of this PHD will be broaden the study of the SiN treatment to different growth technics (molecular beam epitaxy (MBE)) and to other III-N. Moreover, the possibility to grow heterostructures alternating IIISiN and III-N layers will be investigated.

The growth of the samples will be done in CRHEA either by MOCVD or MBE. A special O line has already been installed on one of CRHEA’s MOCVD reactor to study O doping. Both O and Si treatments result in the formation of atomic monolayer thick structures. Their study therefore requires tools with atomic resolution. The samples will therefore be studied by aberration-corrected transmission electron microscopy in IKZ. The PHD student will performed both the growth of the samples and their study by TEM.

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[i] S. Mohn, N. Stolyarchuk, T. Markurt, R. Kirste, M. P. Hoffmann, R. Collazo, A. Courville, R. Di Felice, Z. Sitar, P. Vennégues, and M. Albrecht, PHYS. REV. APPLIED **5**, 054004 (2016)

[ii] T. Markurt, L. Lymperakis, J. Neugebauer, P. Drechsel, P. Stauss, T. Schulz, T. Remmele, V. Grillo, E. Rotunno, and M. Albrecht, PRL **110**, 036103 (2013)