Transmission electron microscopy investigation of III-Nitrides/oxides interfaces at the atomic scale

Laboratories: CRHEA-UPR10, Valbonne, France/ IKZ, Berlin, Germany

Context:

III-Nitrides (GaN, AlN, InN and their alloys) are the materials of choice for the fabrication of optoelectronic devices working in the UV to visible range. They also have applications in electronic. III-Nitrides films are, most of the time, grown on foreign substrates. Due to the differences of structure, chemistry and lattice parameters with the substrates, heteroepitaxial films contain a lot of structural defects. Controlling interfaces at an atomic scale appears as a key point to obtain films with structural properties compatible with applications in both optoelectronic and electronic.

Subject :

The purpose of this PhD is to study the interfaces between III-Nitrides heteroepitaxial films and oxide substrates. Sapphire (Al_2O_3) is certainly the most used substrate for the growth of GaN. As sapphire is nonpolar, but polarity essentially influences physical properties of III-Nitride heterostructures one of the main problems in growth of GaN on c-sapphire is the control of the polarity of the deposited films. The classical GaN growth process by metalorganic vapor phase epitaxy leads to films with a Ga polarity. But recently N-polar GaN growth has been demonstrated opening the way to novel electronic device designs. Moreover, GaN nanocolumns grown directly on c-sapphire have mainly a N-polarity. The first goal of this PhD will be to understand the parameters governing the selection of the polarity on c-sapphire. Alternative polar (ZnO) and nonpolar oxide substrates (In_2O_3, Ga_2O_3,) are of present interest for the growth of III-Nitrides because of closer crystalline structure and/or lower lattice mismatches. The structural properties and growth of such films will also be investigated in this PhD.

Recent developments of transmission electron microscopy (TEM) allow a spatial resolution below 0.1nm. TEM will therefore be the main technique used in this PhD. This PhD will be collaboration between the Centre de Recherche sur l'Hétéroépitaxie (CRHEA) in France which is a laboratory with a large expertise of III-Nitrides growth and the Leibniz Institute for Crystal Growth (IKZ) Berlin which develops new TEM methods for characterization of heterostructures at atomic scale. The growth of GaN on sapphire and the basic characterizations (atomic force microscopy, X Ray photoemission, classical TEM…) will be performed in CRHEA. Then, advanced TEM will be performed in IKZ Berlin.

Candidate :

The candidate should have basic knowledge on the semiconductors structure and should be strongly motivated by structural characterization techniques, in particular by atomic scale imaging.

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