Electron-stimulated III-nitride crystalline phase formation on the sapphire surface in ammonia MBE

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To date, it is difficult to overestimate the importance of the devices based on III-nitride heterostructures for opto- and microelectronics. The formation of high-quality epitaxial structures is complicated by the absence of native AlN and GaN substrates therefore silicon (Si), silicon carbide (SiC) and sapphire (Al_2O_3) are widely used. During development of the III-nitrides epitaxial growth technology, the nitridation (the exposure process of a heated substrate in the active nitrogen flux) as the required initial stage of the growth ensuring the crystal lattice parameters matching of foreign substrates and III-nitride subsequent layers was established.

This work is devoted to the study of the influence of the high-energy electron (11 keV) beam, used in the reflection high energy electron diffraction technique (RHEED), on the initial stage of the III-nitrides epitaxy on the sapphire surface. It was found that a beam of high-energy electrons accelerates the AlN crystalline phase formation process on the sapphire surface by several times. It is related to the fact that during the high-energy e-beam interaction with the sapphire surface, secondary valence electrons are generated and then together with primary electrons cause acceleration of the nitridation process due to electron-stimulated desorption of oxygen atoms and adsorption of ammonia molecules, also stimulating the nitrogen atoms diffusion deep into the substrate.

The correct rate of the nitridation process without the action of high-energy electrons is determined. The effect of the nitridation process completeness degree on the further AlN buffer layer growth is investigated. Optimal parameters of sapphire nitridation (completeness degree, ammonia flux, substrate temperature) are determined, leading to the AlN buffer layer formation with high crystalline perfection and smooth surface morphology (without inversion domains).

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