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Investigation of the influence of molecular and atomic nitrogen ion species during epitaxial nitride thin film growth

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Ion beam assisted deposition (IBAD) enables the engineering of thin film properties by tuning the mobility of adatoms and controlled defect generation during thin film growth. Utilizing ions of hyperthermal kinetic energy in the range of a few 1 eV up to only a few 100 eV the influence of impinging ions on a solid material is limited to the near surface region and hence allows the deposition of compact ultrathin epitaxial films that simultaneously exhibit high crystalline quality. Typically, ion beams in this energy regime are produced by plasma-based ion sources that feature a blend of multiple ion species at distinct, superimposed ion kinetic energy distributions.

In this work, an energy and mass selected ion beam is created, characterized and utilized to deposit epitaxial GaN nanofilms at elevated temperatures. The ion species are separated by a custom and compact quadrupole mass filter system. This well established material system is used to independently investigate the influence of hyperthermal molecular and atomic nitrogen ion species on the resulting film properties during the initial stages of the film growth. In addition, ion energies and material fluxes are varied. The crystalline quality, epitaxial relationship and defect incorporation of the resulting films are evaluated *in situ* by reflection high-energy electron diffraction (RHEED) and *ex situ* by X-ray diffraction (XRD), Raman spectroscopy and transmission electron microscopy (TEM). Film thickness and surface topography are determined by X-ray reflectometry (XRR) and atomic force microscopy (AFM). A correlation between the distinct material fluxes and the resulting growth rate as well as the nucleation process is determined and compared for each ion species. The effects of ion beam sputtering and ion beam induced defects are assessed in dependence on the ion kinetic energy and mass.

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