Effect of N_2/H_2 plasma on the epitaxial growth of InN by hollow cathode plasma atomic layer deposition.

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The high electron saturation velocity, small effective electron mass and high electron mobility of indium nitride (InN) makes it a suitable material for high frequency electronics. The possibility of InN in the existing high electron mobility transistors (HEMTs), currently based on other group III-nitrides. However, InN decomposes to In metal and N_2 gas at around 500°C, making deposition of the InN films challenging with conventional methods such as metal organic chemical vapor deposition (MOCVD) and Molecular Beam Epitaxy (MBE). Nevertheless, Hollow cathode plasma assisted atomic layer epitaxy (HCPA-ALD) is a layer-by-layer crystalline growth technique that is based on a pair of self-terminating and self-limiting gas-surface half-reactions, in which at least one half-reaction involves species from plasma. The inclusion of plasma generally offers the benefit of substantially reduced growth temperatures and greater flexibility in tailoring the gas-phase chemistry to produce varying film characteristics. The benefits of plasma come at the cost of a complex array of process variables that often challenge the ability to predict, a priori, the influence of any one input parameter. This work focuses a variety of gas input flow fractions (N_2 and N_2/H_2) used in the HCPA-ALD growth of InN films. Changes in plasma parameters are then linked with changes in film characteristics. To evaluate the optical properties of the InN films, we use spectroscopic ellipsometer to measure the dielectric function and a complex refractive index. Data were fitted using the Model dielectric function model, and the results show our films have a bandgap of about 1.4 eV, which is bigger than the previously reported values. The Raman spectra showed two Raman active modes of E_2 and A_1(LO) of the wurtzite InN for all InN samples. For InN, we found out that addition of H_2 plasma with N_2 plasma resulted in InN films with poor crystalline quality showing high level of impurities with significant voids in the films, resulting in low-density films with poor adhesion properties. Our results indicate that higher N_2 plasma exposure time is necessary to obtain InN films with minimum amount of carbon incorporation. The presence of C impurities was observed in all films grown with N_2 plasma only and suggests that the N_2 plasma without H_2 is not efficient in terms of effectively removing the ligands of the chemisorbed organometallic trimethyl-metal precursors.

SUPPLEMENTARY DOCUMENT

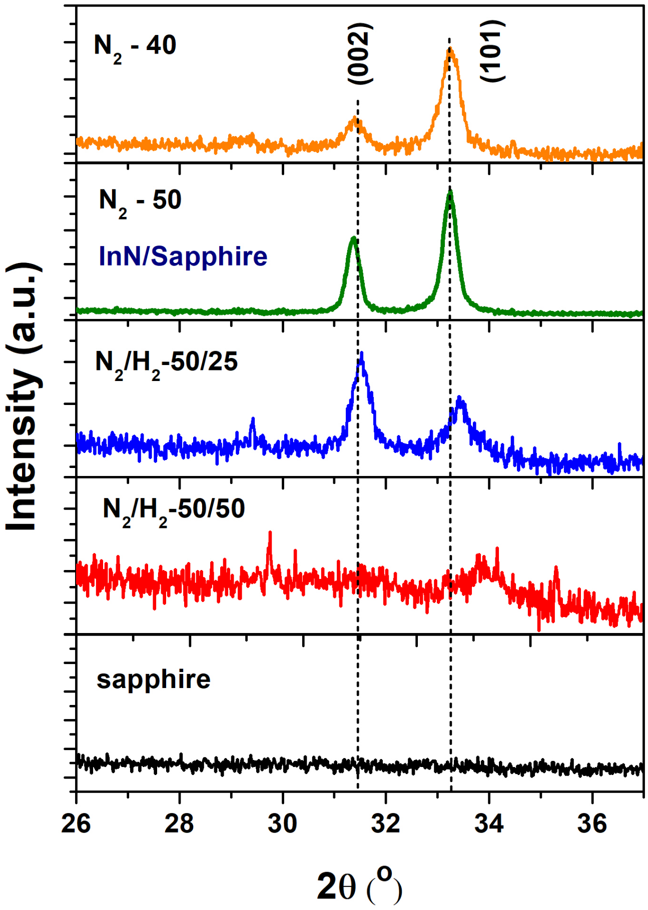

Figure X-ray diffraction patterns of the films deposited at different N_2/H_2 content in the plasma gas.