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Effects of an intermediate c-GaN buffer layer on structural and optical properties of AlN films on MgO (001) substrates

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Effects of an intermediate cubic GaN (c-GaN) buffer layer on structural and optical properties of AlN films on MgO (001) substrates via radio frequency plasma assisted molecular beam epitaxy (RF-MBE) were investigated with Raman scattering, X-ray diffraction, and UV spectroscopy. The samples studied in this work are AlN films grown under Al-rich condition with and without intermediate c-GaN buffer layer. There are 2 types of c-GaN intermediated layers, which are a one-step grown buffer layer with a 7-nm-thick c-GaN layer and a two-step grown buffer layer with a sequence of a 7 nm- and a 200 nm-thick c-GaN layers. Raman spectra recorded using an excitation wavelength of 473 nm of AlN films with a two-step grown c-GaN buffer layers showed the cubic phase related phonon modes at 662 cm^{-1} and 902 cm^{-1}, which are corresponded to TO and LO, respectively. On the other hand, the AlN film directly grown on MgO (001) substrate showed only the hexagonal AlN (h-AlN) related phonon modes at 610 cm^{-1}, 653 cm^{-1} and 884 cm^{-1}, which are corresponded to A_1 (TO) and E_2 (high), and A_1 (LO), respectively. While, the AlN film with a 7 nm-thick intermediate c-GaN layer showed a mixed vibrational modes between c-AlN and h-AlN. As a result, we found out that the structural phases of AlN can be modified from hexagonal to cubic phases with an insertion of a two-step grown c-GaN buffer layer as intermediate layer between the AlN film and the MgO substrate. This result was confirmed by X-ray diffraction measurements, both in $2\theta/\omega$ scan and reciprocal lattice mapping modes. Therefore, a use of an intermediate c-GaN buffer is the key for the growth of highly pure c-AlN film. Besides, results of UV spectroscopy measurements established the Cauchy dispersion relation for reflective index, n (λ), in a range of 200 to 400 nm. For long wavelength limit, reflective index of the c-AlN and h-GaN was examined to be 2.00 and 2.15, respectively.

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