*Acta Cryst.* (2002). A**58** (Supplement), C358

## HYDRIDE VAPOR PHASE EPITAXY OF GaN THICK FILMS AND OBSERVATION OF DEFECT STRUCTURES

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GaN thick films were grown by the conventional hydride vapor phase epitaxy (HVPE) technique. Buffer and main layers were deposited in the horizontal reactor using $GaCl_3$ consecutively. To examine the behavior of the deposited buffer layers at main layer growth temperature, heat treatment was carried out at 900ºC. The deposited buffer layers were investigated by atomic force microscopy and X-ray analysis separately. During the heat treatment, the grown GaN buffer layers were partially crystallized and the amorphous-like grains were aggregated by surface diffusion and merged into the bulky and rough surface film. The optimised deposition condition of the buffer layers was 70sec and 450-550ºC. The quality of the acquired films was comparable to the results of the process using buffer layers by metalorganic chemical vapor phase epitaxy. Because GaN is polar crystal with the space group of *P*63*mc*, various anisotropic behaviors along the polar *c* axis have been reported1. For the simultaneous observation of anisotropic growth behavior along the polar axis, hexagonal-shaped micro-crystallites were grown on the amorphous $SiO_2$ films. From the cross-sectional transmission electron micrograph, various defects such as inversion domain boundaries, nanotubes, dislocations could be observed. The inversion domain extended to the growth surface was confirmed by convergent beam electron diffraction. The domain boundaries shape emerged as linear or curved shapes. Nanotubes and pinholes were widely observed on the film surface. Growth behavior and defect structure related to the crystal structure were examined.

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**Keywords: GAN DEFECT STRUCTURES POLARITY**

*Acta Cryst.* (2002). A**58** (Supplement), C358

## ARSENIC COVERAGE ON GaAs SUBSTRATES USING RHEED DURING MBE GROWTH UNDER HIGH ARSENIC VAPOR PRESSURES

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The surface coverage of As on GaAs (100) at high As pressures was studied from time- and temperature-dependent effects using reflection high-energy electron diffraction (RHEED) intensity measurements. The population of As molecules and Ga atoms on GaAs (100) substrates were controlled by the sequences of opening-closing of the Ga and As shutters. Two initial surfaces with (2x4) and c(4x4) reconstructions at various As pressures and substrate temperatures were examined. The initially c(4x4) surface changed to (1x1) during growth. Only the surface of c(4x4) showed a temperature-dependent disappearance of RHEED oscillations from changes in As pressure, and the effect remained on the surface for about 5 s. When only the Ga shutter was open at relatively high background As pressure, intensity oscillations were observed due to the existence of an excess of As on GaAs (100). The average specular RHEED intensity changed from increasing with time to decreasing with time as the As pressures increased. This indicates an increase of surface roughness with As pressure. This coverage affects the growth rate and hillock heights on GaAs at high As pressures and also at low substrate temperatures.

**Keywords: MBE GAAS , AS OVER LAYER , RHEED**

*Acta Cryst.* (2002). A**58** (Supplement), C358

## EPITAXIAL COBALT SILICIDE FORMATION USING A $Co/TiSi_x$ BILAYER ON (100)Si

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Annealing a $Co/TiSi_x$ bilayer on the Si substrate offers higher probability of epitaxial growth and less Si consumption than annealing of a single Co layer on the Si substrate. Nevertheless the $Co/TiSi_x$ bilayer epitaxy method does not solve the Si consumption problem satisfactorily. In this communication a new $CoSi_2$ epitaxial growth technique of annealing a $Co/TiSi_x$ bilayer on (100)Si is investigated. The X-ray Diffraction(XRD) spectra show epitaxial growth of $CoSi_2$ with the (200) crystallographic orientation on the Si(100) substrate for a $Co/TiSi_x$ bilayer, while the Co-Ti-Si phase was found to form over a silicidation annealing temperature range of 400-600ºC. The Auger Electron Spectroscopy(AES) analysis indicates that native oxides on the Si substrate were removed by $TiSi_x$ at the beginning of Rapid Thermal Annealing(RTA), and then Co diffused to the clean surface of the Si substrate so that an epitaxial $CoSi_2$ film could form. It appears that a new epitaxial $CoSi_2$ layer grows by the reaction between Co and $TiSi_x$ on the top of the seed epitaxial $CoSi_2$ layer formed by the reaction between Co atoms and Si atoms in the Si substrate surface region. The cross-sectional High Resolution Transmission Electron Microscopy(HRTEM) analysis reveals that the $CoSi_2$ layer has grown epitaxially on the Si substrate and the Atomic Force Microscophs(AFM) show that the top surface of the silicide layer is very smooth. Also it is found that Si consumption during silicidation annealing for the $Co/TiSi_x$ bilayer has been significantly reduced compared with that for the Co/Ti bilayer.

**Keywords: COSI2 EPITAXY, CO/TISIX BILAYER, SI CONSUMPTION**

*Acta Cryst.* (2002). A**58** (Supplement), C358

## STUDY ON RAMAN SPECTRA OF THE INCLUSIONS IN KDP CRYSTALS

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Prolate inclusions typically occur in potassium dihydrogen phosphate (KDP) crystal when the prismatic faces expand. Many micron-sized spherical inclusions can be observed through microscope along the pyramid sector boundaries in the crystals with dopant of metaphosphate. These inclusions were probed using laser microscope Raman spectrum technique. In the Raman spectra of spherical inclusion, there is characteristic waveform of water similar to that of KDP aqueous solution ranging from 3200 $cm^{-1}$ to 3700 $cm^{-1}$. Aqueous solution is proved to exist in spherical inclusion as guessed. It is worthy to note that the Raman spectra of the prolate inclusions were different from these of spherical inclusions. Characteristic peak positions such as 1383 $cm^{-1}$ of carbon dioxide, 1149.5 $cm^{-1}$ of sulfur dioxide and 2808.0 $cm^{-1}$ of sulfureted hydrogen appeared in the Raman spectra, besides the waveform of water. The spectra proved that there are carbon dioxide, sulfur dioxide etc in the prolate inclusions as well as solution. We proposed that the compositions differences in above inclusions are related to different growth mechanisms on the prismatic and the pyramidal faces of the crystal. H-bond plays an important role in the growth of prismatic sectors, and electrostatic force dominates the growth of pyramidal sectors. These impurities as carbon dioxide can be easily adsorbed and grown into prismatic sectors by forming H-bond with P-O tetrahedrons. The impurities were also found in the KDP crystals with dense scatters. The results suggested that these impurities are causes for occurrence of the inclusions and scatters in KDP crystals.

**Keywords: INCLUSION KDP-CRYSTAL RAMAN-SPECTRUM**