A4

CHEMICAL VAPOR DEPOSITION OF GaN AND GaP USING a REMOTE PLASMA ENHANCEMENT

CHOI , SUNGWOO and CHO, KYOUNGIK

ETRI, P.O. BOX 8, DAEDUK SCIENCE TOWN, DAEJEON

The remote plasma enhancement has been applied to the chemical vapor deposition of wide bandgap semiconductors such as GaN and GaP. GaN has been considered as a promising material for optoelectronic applications such as visible and near UV light emitting diodes, and blue semiconductor lasers since it has a direct band gap of 3.4 eV[1] at room temperature. GaP is one of only a few semiconductor materials which emit in the visible portion of the optical spectrum[2], even though it has an indirect band gap with low mobility and large effective mass and is therefore largely undesirable for high speed electronic device applications. Recently, the GaP/Si heterostructure has attracted attention, since this structure is to achieve monolithic integration of GaP light emitting diodes on Si.

In the deposition of GaN using remote plasma, the Ga source, trimethyl-gallium (TMG) is not plasma excited whereas the nitrogen- containing gas such as N_2 or NH_3 is plasma excited in a mixture containing a noble gas to form the specific precursors. These precursors in conjunction with TMG control the chemical reaction at the substrate surface and determine the composition of the film at a given temperature. The activation energy for GaN growth has been tentatively assigned to the dissociation of NH groups as the primary N-atom precursors in the surface reaction with adsorbed TMG, or TMG fragments. X-ray diffraction reveals an increased tendency to ordered growth in the <0001> direction with increasing growth temperature, He flow rate, and rf plasma power. Infrared spectra show the fundamental lattice mode of GaN at 530 cm^{-1} without evidence for vibrational modes of hydrocarbon groups[3].

Specifically in the deposition of GaP, the *in-situ* phosphine and phosphorus hydrides are generated from molecular hydrogen and phosphorus vapor in the remote plasma, and interacted with TMG which is not plasma excited. The GaP forming reaction is kinetically controlled with an activation energy of 0.65 eV. The increase of the growth rate with increasing rf power between 20 and 100 watts is due to the combined effects of increasingly complete excitation and the spatial extension of the glow discharge towards the substrate[4]. The homo- and heteroepitaxial GaP films have been produced at the substrate temperature of 590°C or higher. From the depth profiles of the components of GaP/Si heterostructure slight interdiffusion of P into Si and Si into GaP is observed and is compared to the strong interdiffusion in the GaP grown by conventional MOCVD[5]. Using an absorption measurement the value of 2.3 eV is determined for the optical gap of the GaP film grown by remote PECVD. Both homo- and heterodiodes have been fabricated from the above epitaxial structures.

1. H.P. Marusca and J.J. Tietjen, Appl. Phys. Lett. 15, 327 (1969).

2. E.W. Williams and R. Hall, Luminescence and the Light Emitting Diode, Pergamon press, Oxford, (1978).

3. S.W. Choi, K.J. Bachmann, and G. Lucovsky (unpublished data) (1990).

4. S.W. Choi, G. Lucovsky and K.J. Bachmann, J. Vac. Sci. Technol. B 10(3), 1070 (1992).

5. T. Soga, Y. Kohama, k. Uchida, M. Tajima, T. Jimbo, M. Umeno, J. Cryst. Growth 93, 499 (1988).