Interface Reaction Epitaxial (IRE) Growth and Double Buffer Layer (DBL) of AlN on Si using PA-MBE

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1. Introduction

Aiming at growing high quality epitaxial films of group III nitrides and their alloys on a large size Si wafer, a double buffer layer (DBL) of AlN(0001)/β–Si_3N_4/Si(111) has been studied by Wu et. al [1] and present authors [2, 3]. Plasma assisted molecular beam epitaxy (PA-MBE) method, which uses radio frequency inductively coupled plasma (rf-ICP), is the most suitable one for growth of group III nitrides and their alloys on a large size Si wafer[4]. From original Si wafer the DBL was grown by IRE of Si and IRE of β–Si_3N_4 to form AlN. The rf-ICP plasma produces chemically active nitrogen flux and physically active nitrogen molecules flux. Controlling exposure of both fluxes is able to use an activity modulation migration enhanced epitaxy (AM-MEE)[4, 5]. On the DBL an AlN(0001) template is grown by an AM-MEE method of PA-MBE.

In this presentation a new one-chamber system for group III nitride growth on a large size Si wafer using PA-MBE system is shown and the interface properties of the AlN template and Si substrate is studied by grazing incidence-angle X-ray reflectivity (GIXR) measurement [6].

2. Experimental

The nitiridation and AlN growth were performed in the growth chamber of MBE (VG-80H). The nitridation and growth processes were shown elsewhere [4,5]. Surface morphology was measured by atomic force microscopy (AFM). (i) Cleaning and flattening of a Si(111) surface by using SiO_2 film as a sacrifice layer on Si(111) formed by wet processing with HCl and H_2O_2. Si clean surface 7x7 structure was prepared by removing the oxidized film by thermal decomposition by 865 °C. (ii) Pre-deposition of 1 ML(mono layer) Al adatoms on a β-Si_3N_4 layer to form an IRE-AlN DBL: One ML of Al is 22.7 s irradiation at 1050 °C of Al K-cell temperature and the amount of deposited Al on β-Si_3N_4 was controlled by the opening time of mechanical shutter and Al temperature; (iv) A 30nm to 200 nm AlN on the DBL were grown by AM-MEE of PA-MBE. A three layer model of GIXR, which consists of two layers of AlN template, DBL and Si and of the three interfaces of the AlN surface, AlN and DBL interface, and DBL and Si interface.

3. Results and Discusion

Uniform nitridation was confirmed by AFM observation in Fig. 1 obtained from 3 in Si wafer after nitridation in a MBE chamber. White dots on the AFM figure may be protrusion of SiC dots cleated by C contamination. The elimination of these white dots is necessary to get high quality DBL films.

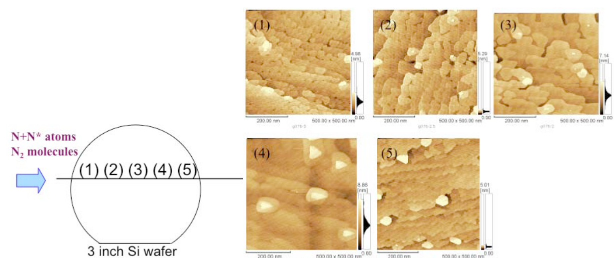

Fig. 1. Uniform nitraidation of 3 in Si (111) wafer using indirect exposure of N+N* flux.

Quality of AlN template films grown on DBL by AM-MEE became high for larger film thickness.

4. Conclusions

Even 3 in wafer experiment the new one-chamber growth system using the DBL on Si for the growth of the group III nitrides was shown effective and promising to contribute high power and high frequency electronics devise fabrication.

References

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