Investigation of bonding interface and strain characteristics in surface activated bonding assisted by Si-nano film

Weicheng Fang [1], Naoki Takahashi[1], Yoshitaka Ohiso[1], Tomohiro Amemiya[1,2], and Nobuhiko Nishiyama[1,2]
Department of Electrical and Electronic Engineering[1], Institute of Innovative Research[2]
Tokyo Institute of Technology
E-mail: fang.w.aa@m.titech.ac.jp

1. Introduction

Surface activated bonding (SAB) based on fast atom beam (FAB) was proposed [1] as a promising hybrid integration method, which can achieve bonded wafer at room temperature without any annealing. Recently, Si-nano film assisted SAB was proposed for SiO_2-SiO_2 bonding, and such material is hard to bond using the common SAB [2]. And we have reported the strong bonding strength and large bonding area in InP/SiO_2-Si bonded wafer using the Si-nano film assisted SAB [3]. In this report, bonding interface is observed by TEM and EDX, and strain characteristics of MQWs before and after bonding is investigated using XRD and photoluminescence (PL).

2. Experimental results

Fig. 1 shows the TEM picture of the bonding interface. In this experiment, 2-inch InP-based epi wafer and Si wafer were prepared for Si-nano film assisted SAB. First, Si-nano film was deposited on the InP wafer by sputtering with a dummy Si substrate. Then the Si wafer was surface-activated by Ar-FAB followed by bonding. After bonding, 350 μm InP substrate and 100 nm GaInAs etch stop layer was removed by the selective wet etching. Two thin a-Si layers are confirmed in the bonding interface combining with EDX results. The upper 5.6 nm a-Si layer is formed by scattering during the pre-bonding process in a high vacuum chamber. As for the bottom 2.6 nm a-Si layer, a trace amount of Ar was detected. This Ar element is from Ar-FAB irradiation during the surface-activated step in the in the high vacuum chamber. Therefore, the bottom 2.6 nm a-Si layer can be considered as the surface crystal layers of Si wafer change to amorphous layers due to the Ar-FAB irradiation.

Fig. 2 shows the PL intensity before and after bonding. Blue shift of peak wavelength can be observed after bonding (The shoulder around 1630 nm in the As-grown sample is the peak of GaInAs etch stop layer, which does not exist in the bonded wafer), and the reason is considered as the strain change in MQWs before and after bonding. Fig. 3 shows the experimental XRD data, in which a slight shift can be seen. As a net value, the strain was reduced by 0.03% (from 0.50% to 0.47%) calculated from the zero-order peak, which was considered to be the strain relaxation caused by removing the 350 μm InP-substrate in the selective wet etching process.

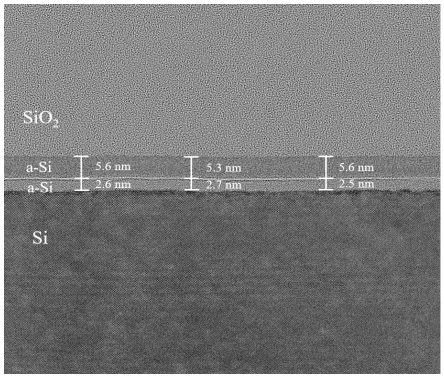

Fig. 1 TEM picture of bonding interface

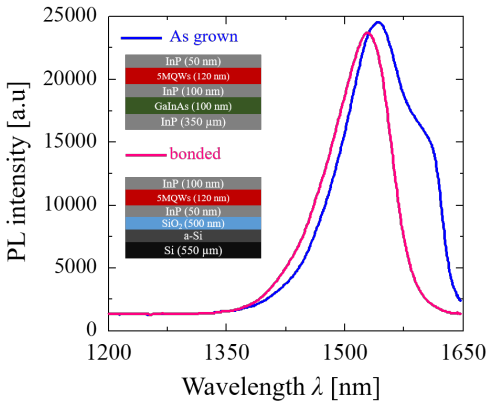

Fig. 2 PL intensity before and after bonding

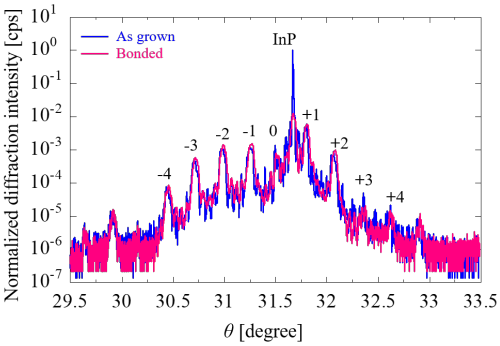

Fig. 3 XRD data before and after bonding

Acknowledgments

This work was financially supported by JSPS KAKENHI Grant Numbers (#17H03247, #19H02193), and JST-CREST (JPMJCR15N6).

Reference

[1] T. Suga et. al., *MRS Internal Meeting on Advanced Materials*, 8, 257, 1989.
[2] J. Utsumi et al., *Jpn. J. Appl. Phys*, vol. 55, 026503, 2016.
[3] W. Fang, et al., *The 80th JSAP Autumn meeting 2019*, 20a-E215-2, 2019.